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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MARCH 14, 1960

NONCIRCULAR GEARS

. . . see page 3

SCIENCE vs ENGINEERING see page 24

ERIC A. WALKER, *President, Pennsylvania State University*

GEORGE B. KISTIAKOWSKY, *Special Assistant to the President for Science and Technology*

WILLIAM H. PICKERING, *Director, California Institute of Technology, Jet Propulsion Laboratory*

A. B. KINZEL, *Vice-president, Research, Union Carbide Corp., President, Engineers Joint Council*

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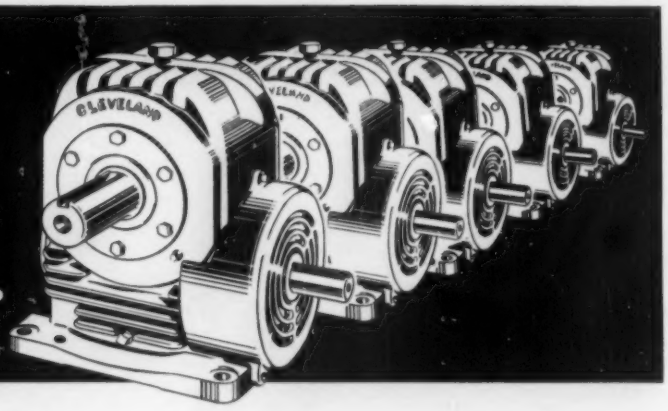

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McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

March 14, 1960 Vol. 31, No. 11

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INTERESTING TO NOTE

Noncircular Gears

Our cover shows but a few of the noncircular gears discussed on page 59. Since these gears are probably the least understood, they are employed infrequently. The first engineer to experiment with these odd-shaped gadgets was the poet, artist, architect, anatomist and scientist, Leonardo da Vinci (1452-1519).

He first thought of noncircular gears when he was studying the crossbow—one of the great instruments of war during the 15th century. Although this bow was not a new weapon, it was still the cause for much controversy. A skilled bowman could split a man's skull with a wooden bolt at a distance in excess of a hundred yards and for psychological impact, whistles were added to the missiles to scare the enemy.

Social and religious groups were horrified when the crossbow was first used in war. "It's inhumane!" they cried. "It's the absolute weapon; there can be no defense!" Some groups tried to have petitions signed, banning its use forever. Apparently, it was humane to pour burning oil on the enemy, but the power and accuracy of a crossbow somehow made it too cruel a way to fight a war.

Da Vinci's interest in war was more than academic. His drawings include plans for the world's first machine gun and tank, and he designed a fort capable of holding off a series of attacks. He also conceived a bomb which, when exploded, would throw off fragments like modern shrapnel. But the crossbow especially fascinated him. In an early attempt to utilize irregular geometric shapes in the production and transmission of motion, da Vinci designed the gears shown at right. They were intended to give added power as the tension increased with gradual drawing of the bow.

Sitting Inside the World

There have been all sorts of suggestions for the world of tomorrow. Walt Disney pictures it as a fairyland; Aldous Huxley, an emotionless world in which people are stereotyped and controlled by science. But what of the world of today? Poets, novelists and philosophers have all taken a crack at describing it. Recently, a company had the opportunity to build a model of our much-maligned globe. At Tulsa's International Petroleum Exposition, the National Supply Co was asked to erect a huge,

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30-ft globe atop a 45-ft building. It was to rotate at 2 rpm, and have inconspicuous supports. The solution (described on p 73) presented some interesting engineering problems. For one thing, the weird acoustics of the giant sphere made it difficult for workmen to communicate while they were piecing together the various orange-peel-like segments. A man five feet away from another couldn't possibly understand him whether he whispered or shouted. But a sound, inaudible to someone five feet away, might build up enough strength to strain the eardrums of another, 30 feet away. Said John Wills, plastics consultant on the project, "I'll swear the first word ever said inside that thing is still going around." He went on to tell PRODUCT ENGINEERING, "I just had to have a ride inside the beast before I left the project. Very strange. I have done a lot of flying in all kinds of aircraft, but never have I experienced the complete lack of orientation I felt in that thing."

Westward Ho!—by Camel

When Hannibal brought his elephants to the Alps, he was one of the first military strategists to transplant animals from one environment to another. As weapons of war, elephants could never acclimate themselves to the high altitude of central Europe. Even our modern jets, with their fast-starting engines (p 68), need pilots burdened with heavy equipment to master the difficulties of high-altitude survival.

There was another interesting—and successful—experiment on the military application of animals on a foreign soil. In James D. Horan's new book, *The Great American West*, he describes how Jefferson Davis, then President Pierce's Secretary of War, drew up plans for a US Army Camel Corps. Davis sent a purchasing expedition to the Middle East to buy the animals necessary to form the new corps, and on May 14, 1856, 40 camels arrived in Indianala, Tex.

These animals met their first test the following year. Edward F. Beale commander of the corps, received orders to perform a military reconnaissance from Fort Defiance, Ariz., to the 35th parallel, on the Colorado River. Purpose of the expedition was not only to find a new route to California, but also to test fitness of the camels in the southwestern plains.

For nine months, a strange caravan, which included 25 camels, undertook the 4000-mile round trip. The

The Great American West by James D. Horan (Crown)

experiment was a complete success—the camels stood the ordeal better than the men, mules or horses. However, when Congress was asked to buy more, it denied the request. The Civil War was fast approaching, and the government was uninterested in camels. After various attempts to use the remaining animals to haul freight, the Army finally disposed of the "desert ships" at public auction.

—Benedict A. Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . New Equations for Circular-arc Cams
This fast mathematical procedure will give the exact dimensions.

. . . A Look into Future Engineering
From research sponsored by the National Science Foundation, examples of the practical results that tomorrow's product-planners can expect.

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Newest process for shaping fabric reinforcement gives high glass content, continuous fibers, and controlled glass distribution.

. . . Faster Way to Set Statistical Tolerances
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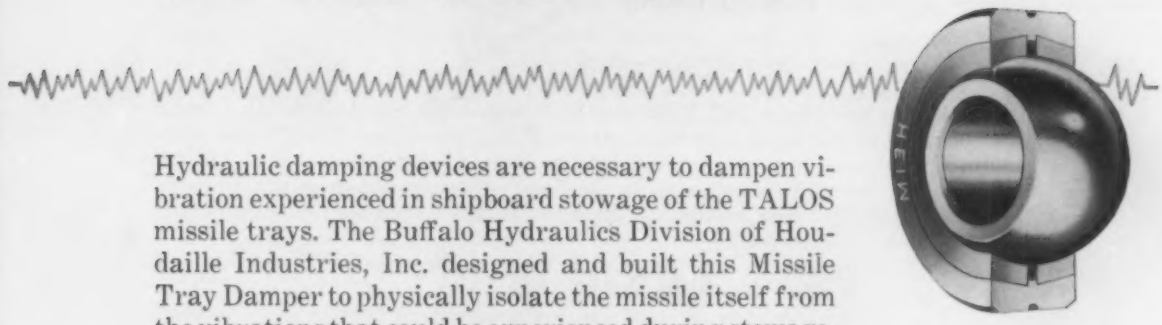
. . . When Instruments Need Feet
These sketches will illustrate many different solutions to the problem.

To Eliminate Vibration

in Missile Trays Stored in Naval Vessel Missile Magazines.



Hydraulic damping devices are necessary to dampen vibration experienced in shipboard stowage of the TALOS missile trays. The Buffalo Hydraulics Division of Houdaille Industries, Inc. designed and built this Missile Tray Damper to physically isolate the missile itself from the vibrations that could be experienced during stowage.

With the misalignment which can be expected of equipment used on shipboard it was necessary to use a reliable, inexpensive self-aligning rod end such as

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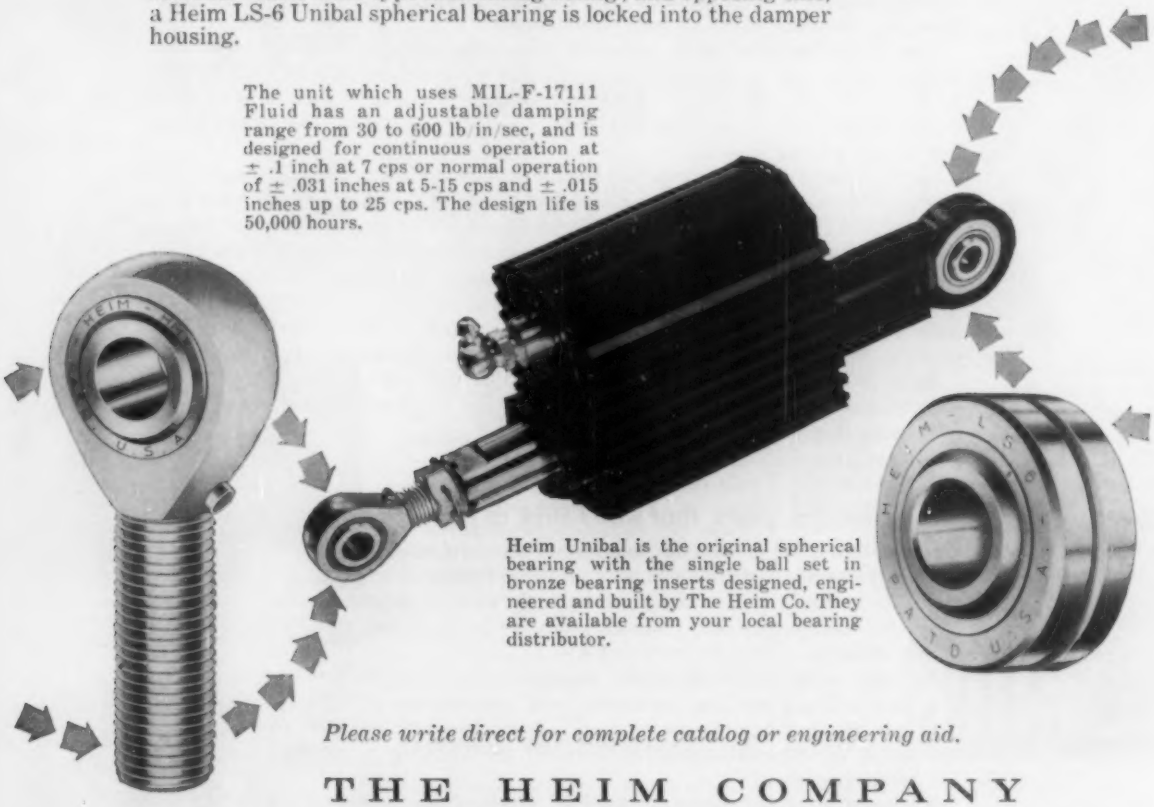

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DEVELOPMENTS TO WATCH . . .

Vacuum melting increases bearing fatigue life

New data on performance of vacuum-melted bearing steels is coming from several government-sponsored research projects.

Reporting to NASA, Syracuse Univ researchers say vacuum-melted tool steels significantly out-perform SAE 52100 and other high-carbon and high-chromium steels produced by conventional methods. At 500 F, they report, the vacuum-melted steels have mechanical properties "at least equal to those of conventional steels at 350 F."

A report by SKF Industries to the Air Force on endurance tests of rolling-contact bearings confirms these findings: "Fatigue life of high-temperature steels is materially increased by vacuum melting."

Significantly, each group found other factors normally considered important, such as hardness, had little or no effect on fatigue life.

The Syracuse researchers say steels with hardnesses ranging from 58 to 65 Rockwell C "exhibit practically identical properties."

And the SKF group found "no correlation of individual bearing life with observed dimensional variations for the same bearings."

Furthermore, the Syracuse researchers report, vacuum melting did not seem to affect tensile and compressive characteristics significantly; in general, there seemed no simple relationship between fatigue life and any static property.

Soviets say new treatments prevent corrosion, enhance appearance

Nickel coatings in attractive colors; dense, shiny combination coatings of nickel and iron; sodium nitrite deposits that protect against corrosion; and improved tin plates are among the recent claims of Soviet metallurgists.

The Soviets are quite specific about the ferro-nickel coatings. Iron and nickel electrodes are used, with an electrolyte containing iron and nickel chlorides (13.356 oz/gal.—3.339 oz of Fe, 10.017 oz of Ni) and a current density of about 3 amp/sq in. Plating is done at about 130 F and citric acid (about 2 oz/gal.) is added to reduce the trivalent iron in the plating solution.

On the colored nickel coatings, the Soviets are less specific, saying only that "nickel coating of metal surfaces in red, blue or yellow instead of a mirror-shine finish has been accomplished for the first time by the Lenin Machine Construction Shop of Slatoust (Southern Ural). Color of the nickel coating was found to depend on duration of the electrolysis process, also on density of the electric current in the tub."

The nitrite treatment, "a most effective conservation method," is a dip in a 30% sodium nitrite bath. Parts to be stored are then wrapped in paper soaked with a 10% solution. Before treatment, though, extremely thorough degreasing is required.

As to tin coating, it's a "high-speed process that uses sulphurous acid, tin sulfate, and tetramethyl-diamino-phenyl methane." It's said to permit coating—at 160 F—at rates better than 1000 ft/min.

Swiss report powdered-metal parts that won't stick at high speeds

Undesirable welding of rotating parts can be prevented, says a Swiss patent, by using specially prepared powdered-metal parts in place of conventional iron or steel. On gun shells, for instance, copper bands are normally used to prevent welding of shell to barrel but, the inventor claims, ferrous bands can be made that are less expensive and equally effective.

He starts with "practically pure" iron or carbon steel powder, and subjects it to a "nonhardening nitriding" treatment (with ammonia gas at 500 to 1000 F). This, he claims, greatly increases wear resistance. A small amount of copper (0.8 to 2%) is also added, by chemical deposition, to lower the sintering temperature and to act as a bonding agent.

A description of the process—in English—may be found in British patent 812,235, issued to Friedrich Hansen, 17 Rue Carteret, Geneva, Switzerland.

Sunbeam die cast appliance part
North Amer. Philips nylon coil form
Dictaphone die cast circuit connector
Westinghouse insert molded insulating screw
Sylvania nylon TV tuner part
Elec. Autolite die cast instrument gear
Ronson die cast lighter part
Stanley die cast power tool part
Samsonite intercast hinged luggage closure
GM acetate car radio part
Union Carbide die cast flashlight part
Argus die cast camera part
Yale & Towne die cast lock part
Western Electric Delrin phone dial part
how many
of these
25 GRC
small parts ideas
can you use
in your business?
General Electric die cast timer part
Lionel die cast model train part
Remington Rand insert cast sensing brush
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Longer lasting electron tubes promised

Electron-tube cathodes which show markedly improved stability of electron emission and "encouraging" life expectancy have been made at Bell Laboratories. The trick, says BTL, is use of ultrahigh-purity nickel as a starting point, with such impurities as copper, iron, manganese, silicon and carbon held to less than 0.01% by weight. BTL has developed a special process for the purpose and is producing several alloys; among them, a nickel-2% tungsten combination looks especially promising.

Abundant supply of materials predicted

Productive capacity for aluminum or nickel, and supply of several other metals will exceed demand for several years to come, predicts Arthur B. Cummins, new president of the Society of Mining Engineers (AIME). And, he says, improved methods for utilization of low-grade ores should assure adequate supplies of iron and steel as well. Furthermore, he points out, if the present trend toward rockets and missiles and other new methods of warfare continues, and the means for conventional warfare (battleships, bullets, manned aircraft) become obsolete, then the requirements, on a large scale, for steel, lead, aluminum, and copper "may be expected to diminish to a significant extent." That means more-than-adequate supplies—barring major emergencies, of course.

Glass to carry fuel for our nuclear reactors?..

Glass fibers as fuel "carriers" for nuclear reactors are now receiving close attention at a number of laboratories—among them, Clevite Corp and Rensselaer Polytechnic Institute. These are glass fibers in which the uranium "fuel" is a part of the glass itself.

At Clevite, aluminum-coated fuel-bearing glass fibers are being developed for use as fuel-rod core materials.

At Rensselaer, it is glass-clad uranium-bearing glass fibers that are under test as major fuel components.

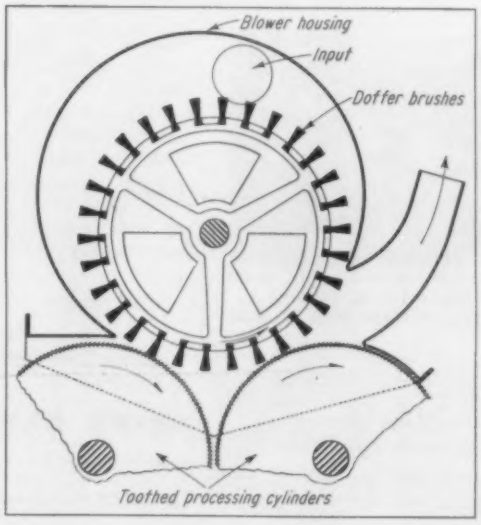
Glass fibers offer a number of advantages for such applications. They are flexible, can be formed or woven into almost any desired shape, can incorporate almost any amount of uranium oxide to give the desired fuel enrichment and configuration. There are, however, a good many questions to be investigated, among them: heat resistance, long-term resistance to nuclear radiation, possible corrosive attack by fission byproducts. However, whether or not glass-fiber fuel elements reach "practical" application, studies like this will provide data helpful for other applications—using the fibers as carriers for other materials and in "piping" of light (*PE*—May 5 '58, p 6).

Double-duty "doffer" designed by USDA

A doffer (lint-remover) that combines two jobs in one—cleaning and conveying—has been designed by US Dept of Agriculture engineers for standard textile equipment.

Traditionally, a doffer removes lint from the toothed processing cylinders by pulling the fibers apart. But, by turning it into the rotor of a centrifugal blower, and using the doffer brushes as blower blades, USDA has made the unit serve as a pneumatic conveyor to carry the lint away, as well as simply to clean the teeth. Furthermore, the unit now cleans two cylinders at once instead of only one as before.

The "Double-Duty Cotton Doffer" (USDA's own term for it) has been patented and is being licensed for commercial production. —ARG



DOFFER BRUSH serves as fan impeller to blow lint through conveyor in new double-duty device designed by USDA for cotton-processing machines.

WHAT'S HAPPENING IN RESEARCH . . .

New guide for nozzle design

A "fallout" test and a throwing-power index that can help evaluate nozzle designs are suggested by B. R. Hinrichs of Karlsruhe Polytechnic Institute.

The test consists in collecting the spray fallout in a number of vessels mounted on the floor of a spray-test chamber. By weighing the collected liquid at the termination of the test, a contour diagram of fallout rate can be obtained, and turned into an instructive picture of the liquid-deposition pattern.

This, says Hinrichs, is markedly superior to photographic measurement of the spray outline, which does not permit quantitative evaluation of the distribution within the spray cone.

Hinrichs has also been testing the effect of changing the angle of the nozzle on "throwing power" of the jet. As an index of "throwing power," he uses the distance from the nozzle at which 50% of the liquid is collected. Throwing power at the optimum nozzle angle, he finds, is about 1.3 times throwing power when the nozzle is horizontal. Furthermore, he says, this figure (ratio of throwing power at the optimum angle to throwing power at the horizontal) can serve as an index of nozzle efficiency.

"Fossilized" magnetism tells age of material

To the list of dating techniques that now includes radioactive decay and thermoluminescent analysis (*PE* —Nov 2 '59, p 12), the British add still another method, based on magnetic moments.

Developed at Paris and Oxford Universities, the technique takes advantage of the discovery that, when iron-bearing materials (pottery clays, for instance) are fired, the magnetic moment of the molecules is fixed or "fossilized" in a direction parallel to the magnetic field of the earth at the time of firing —and they remain in that position indefinitely unless the clay is reheated. Since the declination and dip of the earth's magnetic field change constantly owing to changes in the earth's core, this permits fairly accurate dating of objects by determining the existing orientation.

The British group, headed by M. J. Aitken of Oxford's Research Laboratory for Archaeology, has developed an induction magnetometer for the purpose. The object to be dated is placed in the unit and slowly rotated so that its "thermo-remanent" magnetism generates a voltage in the coils of the magnetometer. This current can then be used to determine the direction of the magnetic field at the time the object was fired. Reference to a time chart of magnetic field position can then give the date of firing.

As the British group points out, there are still problems to be solved. Adequate long-term charts of the earth's magnetic field must yet be developed—and separate charts are needed for each area, because the values for declination and dip vary over the earth's surface. However, charts have been developed for the London area that go back about 2000 years with an accuracy of 1 or 2% and there is no reason why similar charts could not be developed for other areas.

Briefs . . .

Molybdenum can be protected at temperatures to 3800 F in high-velocity hot-air streams, Langley Research Center reports. Tests of small (3 in. by 0.40 in.) rocket-shaped models show chrome plate, Chromalloy W-2, nickel aluminide and flame-sprayed molybdenum disilicide will prevent oxidation under those conditions, for short periods at least (to 1 min.), even when there are small imperfections in the coating.

Chrome-nickel plate; and multiple layers of flame-sprayed zirconia and molybdenum, and alumina and molybdenum; proved unsatisfactory — perhaps because of differences in thermal expansion between coating and base metal, diffusion of gases through the coating, spalling, or a reaction between coating and base metal.

Recrystallization temperature of iron can be raised by additions of the transition elements (Ti, Va, Cr) in very small quantities—less than 1%—E.P. Abrahamson and B. S. Blakeney Jr of Watertown Arsenal reported to the Metallurgical Society (AIME). Many, indeed, have their greatest effect in quantities of less than 0.10 atomic percent. A correlation has been noted, too, between the rate of change of recrystallization temperature and the ground-state electron configuration of the added element.

Copper-titanium alloys can replace bronze, say Soviet metallurgists K. P. Kalinin and M. Z. Spiridonova. According to a report in *Tsvetnye Metal*, copper alloys with 5% Ti, and copper-titanium-chromium alloys containing 5% Ti and 0.5% Cr, "are suitable for replacing beryllium bronze" in structural applications; and they've tested and charted strength, hardness, and solubility data.

Ultrathin copper wire can be made by a pressurized-gas extrusion system, the USSR Academy of Science reports.

The pressurizing gas is nitrogen, which forces the molten metal through a tiny hole in its container. As the metal emerges from the opening, it is immediately cooled by an air blast.

Advantages claimed for the system, which can produce wire less than one micron in dia, include materials savings through reduction in size of charge and in production waste, and a higher quality product.

Irradiation raises the brittle point of steel, but not enough to cause any serious damage in the reactors now built or contemplated, says Sir John Cockcroft, UKAEA. Calder Hall reactor studies indicate the rise in transition temperature will be no more than 45 F in 20 years of operation; and not more than 90 F in the big commercial reactors now under construction. This indicates that, if reactor temperature and neutron flux are held within design levels, there will be little danger of equipment failure from this cause. More serious problem: fuel-element failures traceable to weld and stress failure in the protective magnesium alloy cladding and possible overheating of this alloy which ignites at about 1170 F. —ARG

1 Vinyl latex gives do-it-yourself paints greater:
(a) scrub resistance *(b) one-coat hiding power*
(c) freedom from lapping and streaking

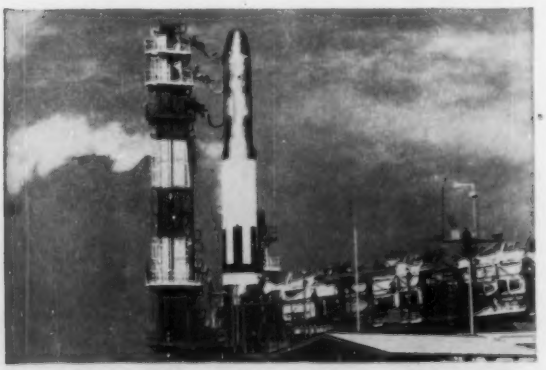
2 Rich, leather-textured finish on this auto top is:
(a) baked vinyl coating on steel *(b) vinyl coating on cloth*
(c) molded vinyl sheeting

Can you pass this test on Vinyl plastics?

(You'll discover more of their potential as design materials)

3 What parts of her shoes are molded vinyl?
(a) the soles *(b) the heels*
(c) the whole shoe

4 Well-dressed lambs wear vinyl film to:
(a) make them easy to find *(b) keep oil off shepherd's hands*
(c) protect against rain and cold



5 Chief advantage of vinyl jacket for missile control cable is:
(a) light weight *(b) flexibility*
(c) resistance to oxidation

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2. (a) Textured vinyl coating on steel looks like leather—wears like iron.
3. (c) The whole shoe—waterproof, tough, glossy and scuff-resistant.
4. (c) Protection against weather—cuts drastic winter lamb mortality.
5. (c) Resistance to oxidizing effect of rocket fuel vapors. Light weight and flexibility contribute to ease of handling.

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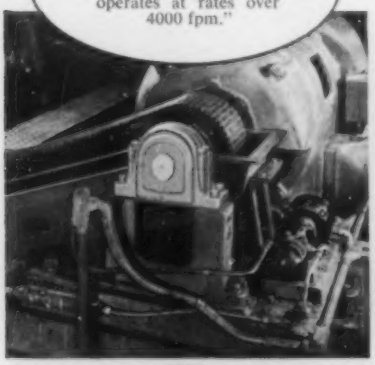

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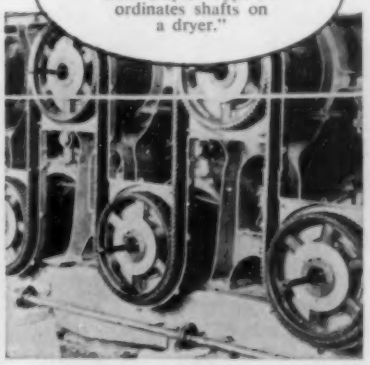
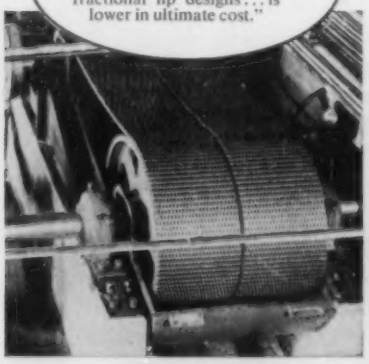


"Silent Chain can be installed on extremely short centers at ratios as high as 10-to-1, with resulting space economies."

"Link-Belt Silent Chain delivers better-than-98% efficiency on large or fractional hp designs . . . is lower in ultimate cost."



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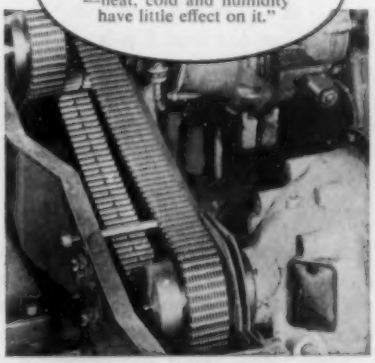

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FROM WASHINGTON . . .

Add at least another billion to Ike's defense budget

The political debate over defense will be heightened in the months ahead as election day nears and as Russia adds new feats in rocketry (some spectacular ones are anticipated) to its diplomatic maneuvering.

As the debate now stacks up, odds are that Congress will add an extra billion or so to the Eisenhower administration's $41-billion military budget.

Development projects will be favored in the expected budget increase. The Air Force's B-70 bomber program (North American Aviation), which was severely cut in the administration's recent economy drive, stands out as the biggest candidate for extra funds. Congressional leaders are sympathetic to the Air Force's plea to speed development of a Mach 3 airplane.

The Minuteman ICBM, MIDAS early-warning and SAMOS reconnaissance satellites, and Sky Bolt air-launched ballistic missile are other air development projects likely to be pushed harder by Congress.

On its own, the Air Force is already speeding up work on MIDAS.

An Air Force general told PRODUCT ENGINEERING that "we are short of money for this project and are reprograming fiscal-1960 funds for it." The project's original budget this year totals $59.7 million; **spending is slated to rise to $102 million next year.**

Air Force isn't seeing things the NASA way

The Air Force-AEC team working on the "Rover" nuclear rocket development project charges the National Aeronautics & Space Administration with foot-dragging. The team has responsibility for proving the ground feasibility of a nuclear rocket; NASA has the responsibility for following up with a timetable requirement for actual flight applications.

Col. Jack F. Armstrong, assistant USAF-AEC nuclear-rocket development chief, told Congress that KIWI-A reactor experiments last summer proved Project Rover's feasibility beyond all expectation, but that NASA's failure to set early flight requirements is holding the project back.

Says Armstrong: "A nuclear device can be flown in the relatively near future and do a useful mission. I think the first peaceful use of nuclear energy in space will be a major breakthrough attracting far more acclaim than getting the first satellite into space. And I'd like to see the Stars and Stripes on it, for a change."

Also argument concerning super rocket boosters

The Air Force and NASA are crossing swords on still another project—development of super rocket boosters. The White House recently assigned the civilian space agency full control, with responsibility for new engines producing at least 1 million lb of thrust. The Air Force's F-1 giant, single-chamber engine project (North American Aviation's Rocketdyne Div is the prime contractor) was transferred to NASA in line with this decision.

But Air Force is now moving back into the field with a plan to develop a giant solid-propellant rocket in the million-lb-thrust class. Invitations went out a few months back for rocket builders to submit proposals to the Air Force "to demonstrate the feasibility" of such an engine. Six companies are now bidding for the work. A feasibility-study contract will be awarded shortly.

Air Force stresses that the new project will not involve a usable engine; work will be limited to study efforts. But Air Force experts have made no secret over their dissatisfaction with NASA efforts in the superbooster field. They want the work speeded up, and they're more interested in solid-propellant engines. NASA is stressing liquid-propellant superbooster engines.

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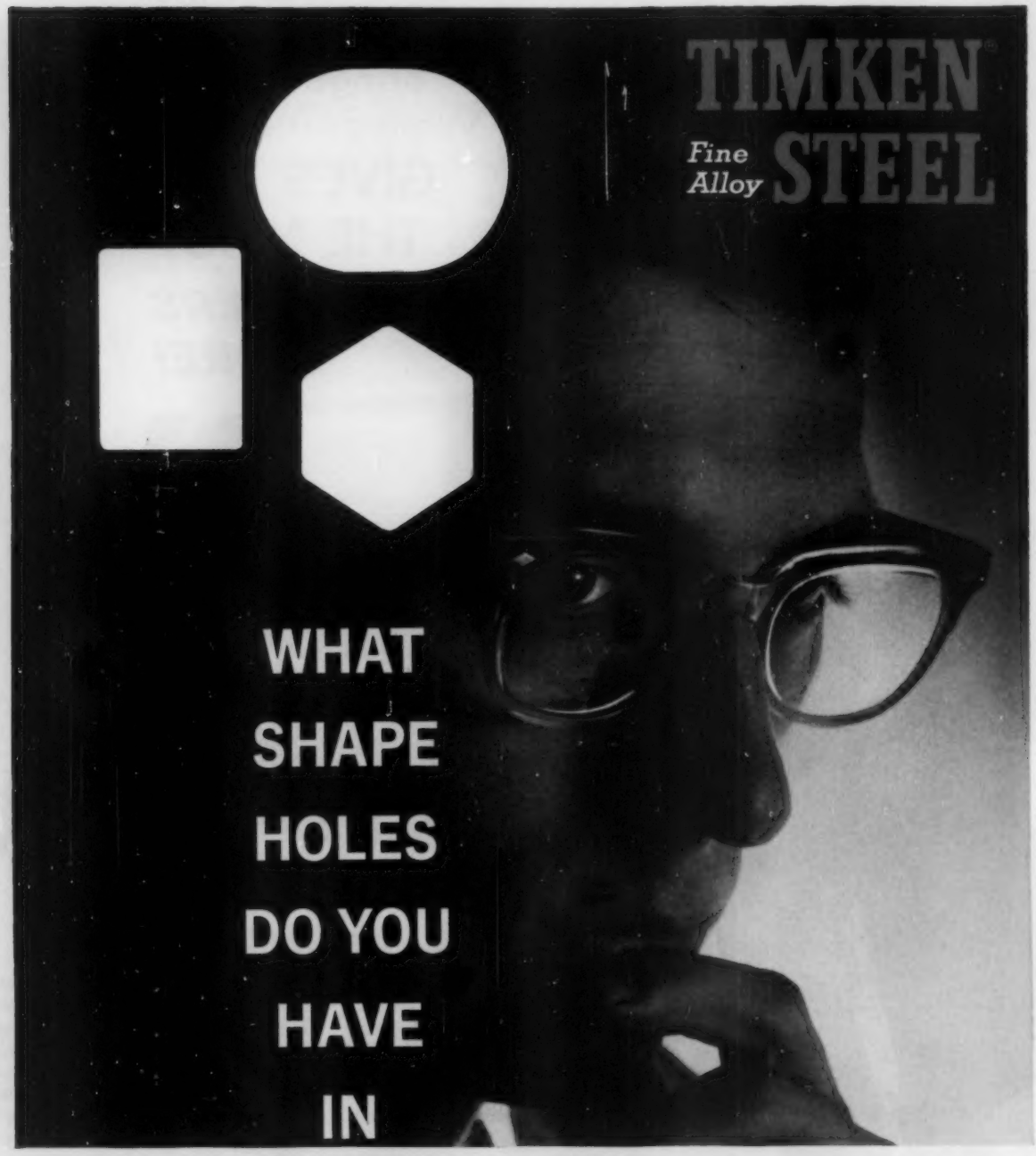

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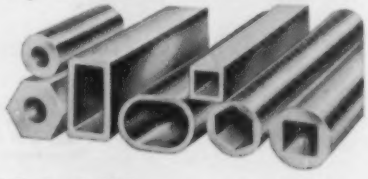


See us at the Atomic Exposition, New York Coliseum, April 4-7, Booth 228

Microfilm to Cut Red Tape for Air Force Contractors

NEW YORK—The Air Force is seeking to break the log jam of paperwork for its contractors by requiring that all engineering drawings be submitted on 35mm microfilm, along with aperture cards on which the film can be mounted. The system is called Micro-mechanized Engineering Data for Automated Logistics (MEDAL) and is being administered by Air Materiel Command, Wright-Patterson AFB.

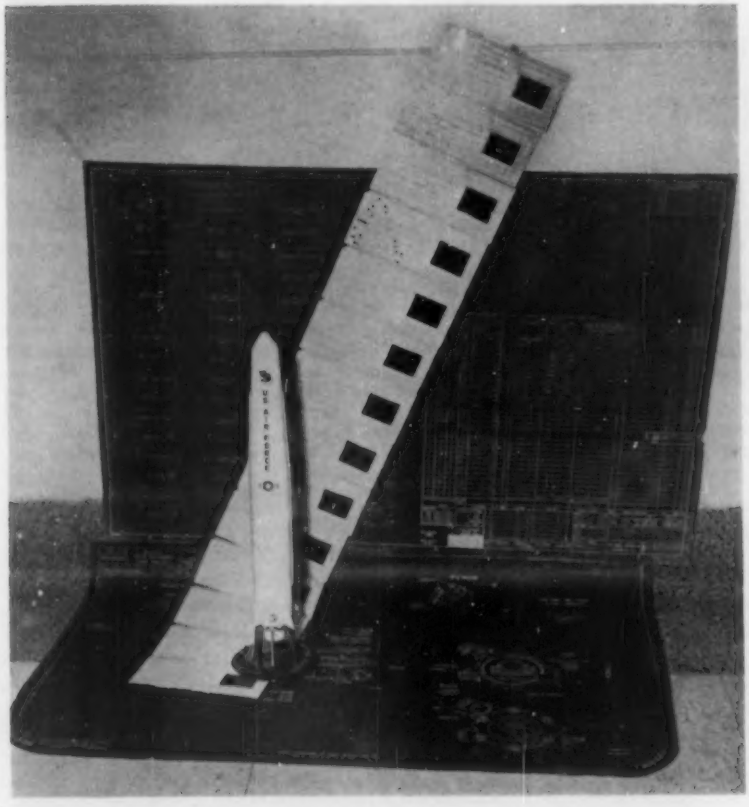
The three-year program, begun late last year, will be evaluated by the Defense Dept for application by all services to its industry contractors and subcontractors. Defense Dept has already standardized all engineering-drawing sizes—Mil-D-70327 replaces 40 other military specifications—but compulsory microfilming for Army and Navy depends on MEDAL.

Previously, for a major-weapons system, a prime contractor had to supply Air Force with 50,000 reproductions as well as up to 1½ million prints; a costly, time-consuming effort. Such a system required 7½ million sq ft of paper plus 250,000 sq ft of reproducibles. Photo below compares size of microfilm cards and blueprint.

Since 1950, when the Air Force decided that microfilm might be the answer to this problem, there has been steady improvement in microfilm equipment, cameras, duplicators, enlargers, printer-readers, and viewers (*PE—Mar 17 '58, p 19*). But duplicates of the filmed drawings still had to be kept, so distribution to air depots and bases remained unwieldly.

Development of the aperture card (ordinary punch card in which a square opening has been die-cut so that a frame of microfilm can be inserted) has opened the door to a streamlined program. Now, the contractor has only to supply the Air Force with the following:

- one set of 35mm microfilm
- one microfilm index
- one punch card for each drawing
- one punch card for each frame of microfilm
- one punch card for each vendor item in an end assembly



HOW MEDAL WORKS

Microfilm and cards received at AMC are checked for resolution, density, image-centering, frame-spacing and other factors prescribed in Mil-M-8857 (ASG). All data up to 22 x 34 in. must be microfilmed at 16X; all sizes of 11 x 34 in. must be filmed at 24X; all larger sizes at 29X.

A proofing operation guarantees that the film index is complete and accurate; a verifying operation ensures that punch card and film data match. If the number of rejected frames is less than 20% the Air Force asks the contractor to resubmit the rejected data. If the number exceeds 20%, the entire roll is rejected.

The Air Force turns over to a microfilm contractor the inspected cards and films. From the master film, the microfilmer makes a positive intermediate and the necessary duplicate rolls for distribution decks—all are silver halide.

Three decks of the Punch-Card Accounting Machine (PCAM) cards are data-processed: The index deck consists of a PCAM for each piece of data required in a complete set for a given item. Once an index deck is furnished, only updating changes are required. The dummy deck contains a PCAM card for each frame of microfilm including targets, rejects and skips. Number of frames used in filming a data set is determined by the microfilmer. The vendor deck consists of a PCAM card for each vendor item in the complete assembly of the end item.

Film can then be mounted on the cards and distributed to Air Force depots and bases. An automatic machine can mount 2000 cards per min; a manual device can mount 125 per

min. Mounting and data processing is accomplished by the Air Force with the intermediate roll kept in central files as the master copy to which changes are applied annually.

Air Force hopes to apply computer techniques for microfilm data retrieved from central file. One such device is the Stromberg-Carlson high-speed microfilm printer which can operate to print characters or plot graphs on a Charactron shaped-beam tube face. Characters from tube face are then projected onto 35mm film at a rate of 15,000 characters per sec and plotting 10,000 points per sec.

Major advantage of film over prints for distribution purposes is that microfilm is a miniaturized reproducible. Each Air Force unit, after viewing a PCAM card with mounted film, can decide on its own reproduction needs. Extensive reproduction of unnecessary prints will be eliminated.

Another saving is in cargo space. One cargo plane can transport 70 times as many aperture cards as full-size reproducible prints. In addition, the central repository, which must house some 4 million reproducibles, would prefer to store aperture cards which require only 0.139 cu ft per 1000 as opposed to blueprints taking up 9.6 cu ft of space per 1000. Filing, relocating and other clerical operations that require 17 man-hours under the old system will now take only 9 man-hours.

To date, one million drawings at AMC headquarters have been put on aperture cards, one-eighth of the goal for the three-year program. Air Force expects that by 1962 the central files and the print files in the field will contain some 90 million aperture cards.

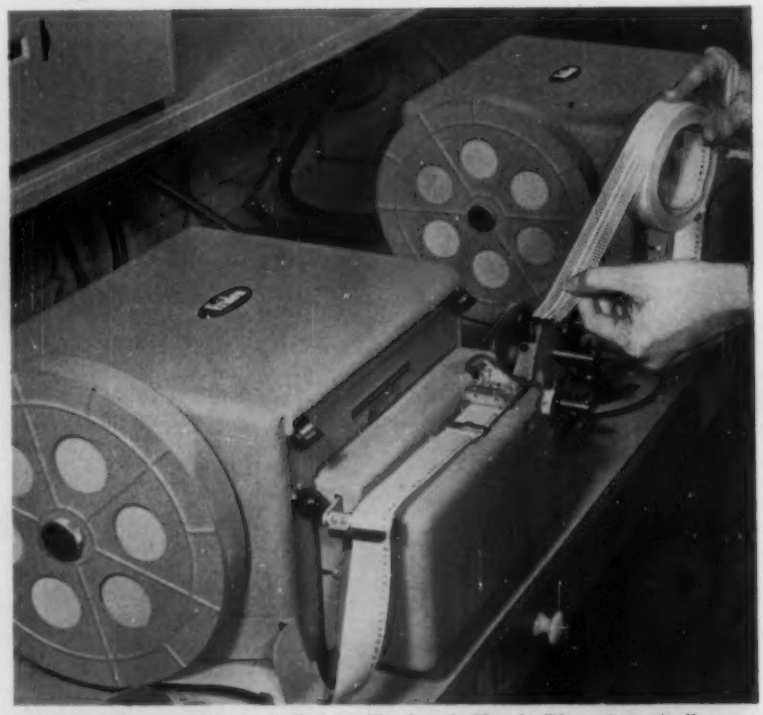
Meanwhile, the Army and the Navy have been experimenting with aperture-card microfilming. The Philadelphia Navy Yard has applied micromechanization to a number of weapons systems, while Army Ordnance and Signal Corps have tried it on a limited basis.

Initiation of the MEDAL program comes as no surprise to major contractors, many of whom have long had the necessary equipment to comply with Mil-M-8857 (ASG). As far back as 1954, Lockheed Aircraft Co was investigating Filmsort Co's aperture-card service. However, cost of the cards at that time ($42 per thousand) was prohibitive for any large-scale program. Filmsort Co has since been bought by Minnesota Mining and Mfg Co and current price is $27.50 per thousand.

Generally, the Defense Dept is enthusiastic about standardizing drawings and microfilming, but there are bugs to be ironed out.

A revision of Mil-D-70327 is now in the works. One meeting has been held by the military with industry, and a first draft of changes is being written for distribution by the end of next month. By midsummer, Defense Dept hopes to have revisions completed. Main problem appears to be that of prime contractor getting standard drawings from subcontractors. ■

Taking Clerks Off Clerical Work



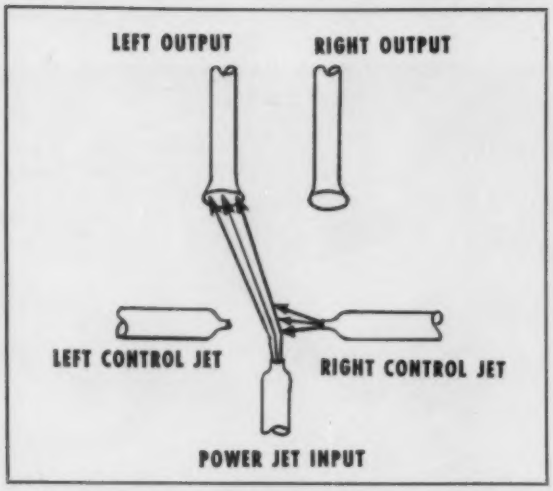
High-capacity computer installed by Northrop's Norair Div automatically produces reports on production, performance and labor; insures control of location and movement of 30,000 production orders daily. Called "Automated Operations Control," the technique eliminates 42% of manual key-punch time, will cut the work of shop clerks by more than 425 man-hours daily. System (above) combines Friden Corp's automated data-collecting and transmitting equipment with Norair's IBM 704-equipped computing and datamation center. System functions around two working information files: a master operations file containing all fixed information on formally planned production masters required to produce all parts, and a master work-in-process which serves as memory for the system. Information obtained from 97 transmitters and three data-receiving stations is stored in the computer.

Too Many Chiefs, Not Enough Technicians

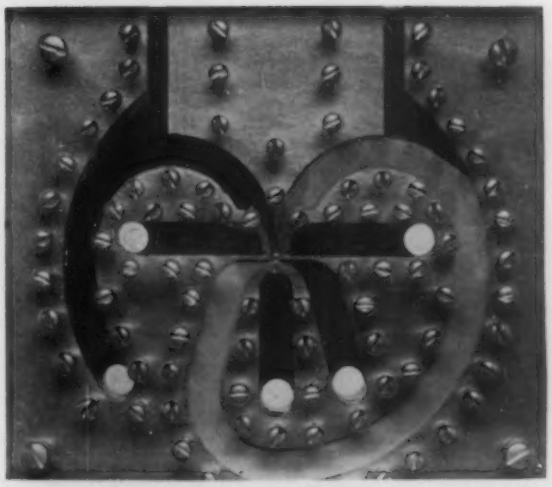
BOSTON—There are only seven technicians for every 10 engineers in the US.

Result: too many engineers are doing the work of technicians. This is the conclusion of Dr Frank Lee, manager of training services for Raytheon Corp. (See page 55.)

Dr Lee reports that because only four of the seven technicians are trained in technical institutes, the other three must be educated by companies like Raytheon. Urging better classification and utilization of technical manpower, he points out that while the US trains 100,000 technicians annually, the Soviet Union turns out 900,000 each year. ■



FLUID AMPLIFIER shown in schematic will work with gas or oil. Power jet is easily deflected by low-energy control signal, and there are no moving parts. Actual model of the new amplifier has special built-in feedback feature that keeps power jet aimed towards last called-for output even after control signal has been removed. For example, lighter area is feedback channel for right-hand output. Power jet is at bottom.



No Moving Parts for Fluid Amplifier

WASHINGTON—Oil or air circuits may soon compete for control applications previously thought suitable only for electronic and electrical controls. Reason: a simple new fluid amplifier just unveiled at the Army's Diamond Ordnance Fuse Laboratories here. Development of the amplifier, which uses either a gas or liquid and has no moving parts, is a fundamental breakthrough according to Richard S. Morse, director of research and development for the Department of the Army, one of the spokesmen. Several actual devices were demonstrated by the inventors—civilians at the laboratories: B. M. Horton, chief of systems research; Dr R. E. Bowles, chief, and R. W. Warren, research supervisor, of nonradio systems branch of DOFL.

The new fluid amplifier in its simplest form (see diagram) has a power jet that is deflected to the desired output chamber by directing a control stream against the side of the jet. The control stream needs only a fraction of the energy of the power stream, and the resulting power amplification can be as high as 100:1.

Photo above shows a more sophisticated model. Still another version of the amplifier (not shown) has specially contoured flow passages that take advantage of a boundary-layer phenomenon between power jet and walls. Power jet tends to hug the wall as soon as it gets close, and a lower energy control signal will work.

Advantages of the new concept are many. Wear and maintenance are negligible because there are no moving parts. Operation at white heat is possible if the fluid is air and the body is ceramic. Uniform temperature variations will not affect performance. Construction is simple: nozzles and passages can be made with printed-circuit etching techniques and will cost less than transistors and vacuum tubes for equivalent applications; size can be from extremely small (0.005-in. orifice) to any large size. And fire hazard is reduced because electricity is not used.

Any power output from nearly zero up to 100's of hp—and even higher—can be achieved by making the power-jet nozzle large enough to handle the required flow. Control-jet nozzles must also be proportionately larger, but staging of several fluid amplifiers in series will raise the signal energy to the higher levels. Output is pure velocity, but diffusers can convert a large percentage of this kinetic energy into pressure for operating control elements such as pistons and motors. Overloading the output or even blocking its flow has no permanent effect on the deflection of the power jet. The flow will divert to the unblocked outlet until overload is corrected, then automatically return to proper outlet.

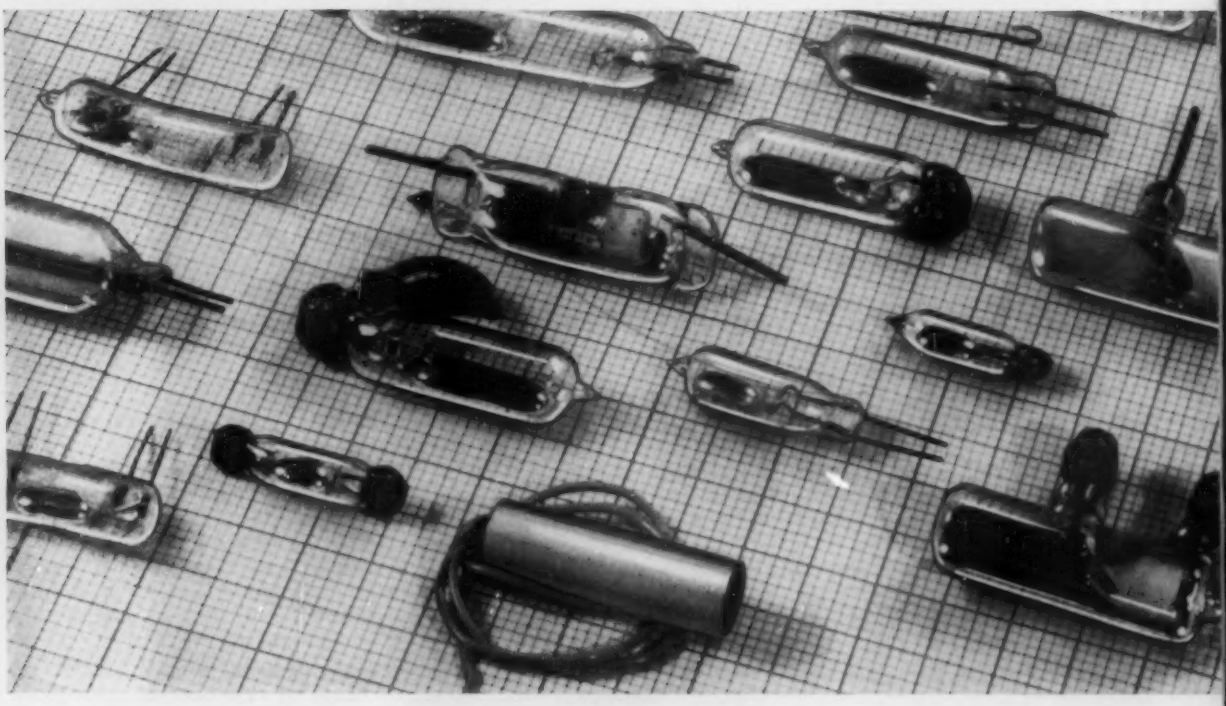
Response time depends on size of device selected, and can be as high as 20,000 cps for simple, small systems. Linearity is equivalent to conventional servovalves—without their problem of sticky pistons. Power and control pressures from inches of water up to 500 psi have been tried, and there appears to be no restriction. And performance is satisfactory at all flows from subsonic through transonic right up to supersonic.

Limitations are few: it cannot transmit over long distances, because line volumes are too great and transmission velocities too low; it cannot operate at much higher than audio frequencies; and there must be a supply of pressurized gas or liquid.

Hope was expressed by a government spokesman that industry as well as the military will seek to develop this new concept into actual hardware soon. Suggested control applications are for computers, automatic washing machines, machine tools, missiles, and aircraft. Look for coming feature article by the inventors on the new concept.—Frank Yeaple.

continued on page 20

Fresh approach for switch problems:



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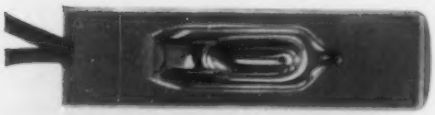
They are hermetically sealed in glass to resist dust, oil and water. That construction assures a far longer life, yet their cost is usually lower. Installation is easy, with no complicated operating mechanism needed. There are hundreds of mercury switches in the Honeywell line with different electrical ratings, contact arrangements, operating characteristics, lead wire and terminal variations.

Mercury switches are now being used in electronics, ultra-precise military applications, automatic washers, animated displays, freezer lids, as split-second pulse switches, and for control of resistive and inductive loads.

MICRO SWITCH engineers can help choose the correct mercury switch for your application. See the Yellow Pages for the nearby MICRO SWITCH field office, or write for Catalog 90.



SHOCK-PROOF CASES. Mercury switches are available potted in resilient material and enclosed in metal and nylon cases to protect them from shock and splashing chemicals.

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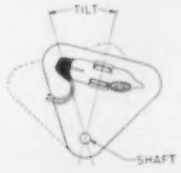
MICRO SWITCH Precision Switches

Many design ideas can be built on the simple, sealed switch operation shown above.

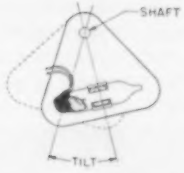
MERCURY SWITCHES

A FEW OF THE MANY MOUNTING AND ACTUATION METHODS

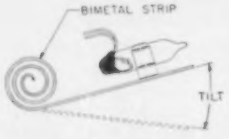


Over-center for quick contact.

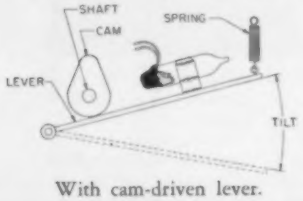
On-center in minimum space.



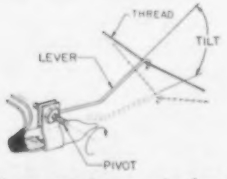
Below-center, low operating force.



On bimetal strip, temperature control.



With cam-driven lever.



Pivoted actuator detects wire break.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

Engineer Grads to Get Better Offers This Year

NEW YORK—Early reports from campus recruiting offices indicate that industry is courting the graduating engineer this year with greater urgency than ever.

"This could be a record-breaking year," says John A. Bornemann of Columbia Univ. "Demand will continue unabated for electrical and mechanical engineers, mathematicians and physicists."

He adds that 200 companies are seeking mechanical and electrical engineers at Columbia, but only 20 mechanical- and 40 electrical-engineering students will graduate in June.

An estimated 230 companies will interview 216 seniors at Stevens Institute of Technology during the school's six-week interviewing period, which runs from Feb 15 to Easter. Harold Fee, director of placements, predicts that there will be more job offers and more interviews for each senior than last year. In 1959, students averaged 16 interviews and 3 job offers.

At Polytechnic Institute of Brooklyn, 250 recruiters are expected on campus before the season ends in May. They will be looking over 400 graduating seniors. These recruiters have more jobs to offer than last season. Statistics are incomplete but it is estimated that recruiters have an estimated 20,000 job openings. This is 5000 more than last year.

Though recruiters are not as selective as they were two years ago during the recession, they are still primarily interested in the top students, according to an NYU placement officer. About 230 to 250 companies are expected on NYU's campus by April. Last year, students averaged 3 to 4 offers apiece. This year, they are expected to fare as well or better.

Starting salaries will climb again this year under the pressure of increased demand. Bornemann foresees a 2 to 3% hike in salary offers for Columbia students. Last year the median salary for a BS ran $520 a month. NYU finds electrical engineers favored in the early canvass. They will be averaging $535 to $550. Mechanical engineers will average $495 to $520; chemical engineers, $480 to $495. ■

Guillotine Test for Spray-on Vinyl

How do you measure cut-resistance of paint films for dishwashers? General Electric engineers at Appliance Park, Louisville, Ky., came up with this nonlethal throwback to the 18th century to help select an interior finish for company's Mobile Maid dishwasher. Coated panel under test can be tilted up to 65° to simulate impact angles encountered in washing cycle. Complete cut-through is signaled by completed battery-light circuit. Finish that finally passed this and other GE evaluation tests was a spray-on vinyl plastisol developed by Metal & Thermit Corp. Called Unichrome, the new vinyl coating (PE—June 28 '59, p13) can be applied in either plastisol or organosol form, and costs less than vinyl laminate, but slightly more than precoating with plastisols. For production applications, M & T engineers give these total costs per sq ft of 0.041 steel with a 12-mil coating: Laminated, 32.9¢; precoated with plastisol, 26.6¢; Unichrome plastisol, 28.6¢.

First Cadmium Sulfide Transistor Developed

WARREN, MICH—A new cadmium sulfide field-effect transistor, believed to be first of its kind, has been developed by General Motors Research Laboratories. But it is still an experimental device rather than a commercial product.

Cadmium sulfide (CdS) is a compound semiconductor material, unlike those that are elemental materials—such as germanium or silicon—those containing only one kind of atom. Various compound semiconductors are being subjected to extensive research in many laboratories, but few transistors are made from them.

Electrical properties of CdS are greatly affected by light and other radiations, and these photoconductive properties make the new GM CdS transistor unique among circuit devices. Its amplification can be controlled by changing either the color or intensity of light striking it, according to Dr Gerald M Rassweiler, head of GM research physics dept. Other differences contribute to making it more useful than present commercial transistors in certain circuit applications.

Although still experimental, the CdS transistor has been successfully operated in oscillator, multivibrator, amplifier, and radiation-detection circuits by Robert Bockemuehl, senior engineer in charge of its development.

In a recent report on the project, Bockemuehl pointed out that "unique characteristics of field-effect phototransistors allow them to perform new and combined circuit functions that are not practical with conventional circuit elements."

Bockemuehl explained that CdS does not compare with germanium for general transistor applications, but said the GM device has certain advantages as an amplifying photosensitive element; its amplifying properties can vary greatly, and uniquely, with light intensity and wavelength.

"Furthermore," said Bockemuehl, "these solid-state phototransistors have the small size, high efficiency, and ruggedness common to semiconductor devices. Both the output and input resistances of the CdS transistor are higher than normally encountered with junction transistors and vacuum tubes. Conventional amplification at a fixed light level is possible; however, efficient coupling to other active circuit elements is difficult and its advantageous use as an amplifier is limited to low-frequency applications requiring high-impedance levels, such as photomultipliers or ion-chamber amplifiers." ■

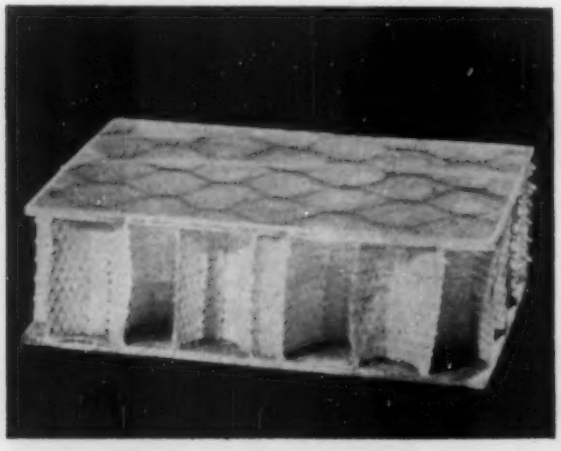
Now—Woven Honeycomb for Sandwich Panels

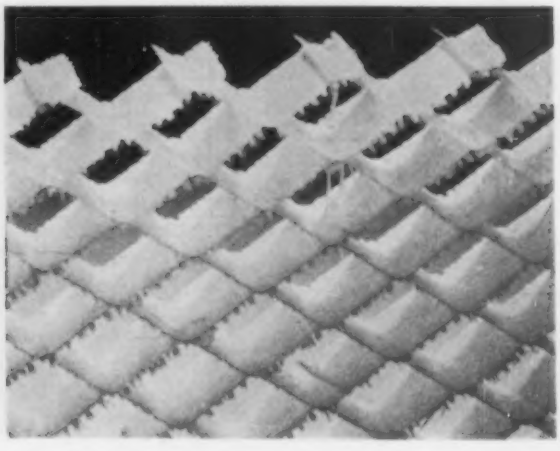
LOS ANGELES—By weaving cloth in multiple layers on a special loom, the Raymond De-Icer and Engineering Co has come up with a way to make cellular fabrics that are suitable—when impregnated with a reinforcing plastic—for lightweight cores in sandwich panels. Main advantage of woven honeycomb is that the node point is mechanically and positively locked—the warp yarn crosses back and forth from cell to cell.

The new process has additional advantages. Previously, fabric honeycomb was made by impregnating the woven sheet, corrugating it over a gear-shaped wheel, and curing it in this shape. Separate panels were then assembled by applying adhesive to the nodes and stacking—an expensive process. In addition, failure of a single joint could cause rejection of an entire assembly.

The loom can be programmed to produce multilayer fabric with either hexagonal cells (below left) or square cells. Preliminary tests show square-cell construction to be 10-15% lighter than hex-cell fabric for the same strength. This is because more of the warp yarn (up to 50%) is carried through each node joint.

Multilayer honeycomb can be made of almost any weaveable fiber. Glass yarn is the major material employed to date, with impregnated densities possible (without facing panels shown below) from 2 to 10 lb per cu ft. Other fibers that have been tried successfully include cotton, nylon, stainless steel wire, and other special drawn wires. Mixtures of dissimilar fibers for special purposes—stainless and glass, for example—are feasible and are under development. (For more on weaving as method of making 3-D reinforcement, see Contour Weaving in next week's PRODUCT ENGINEERING.)





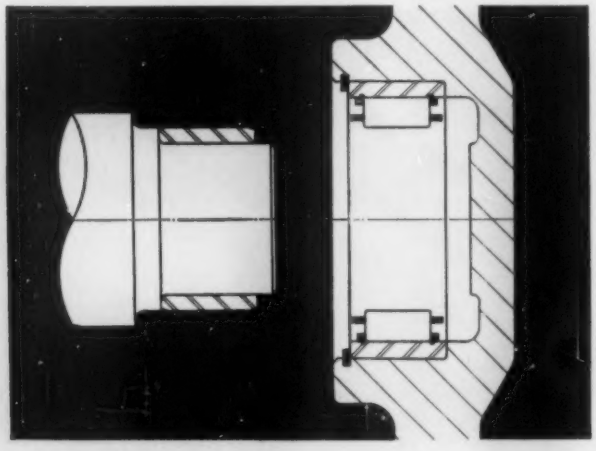
ALL THESE SOLVED WHEN

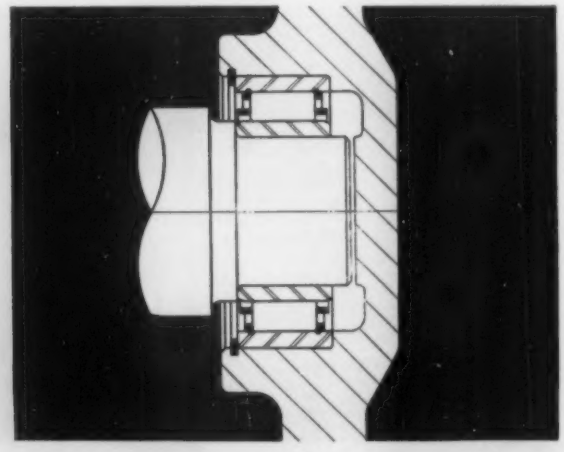
SAVE COST

Again, how simple this shaft becomes when you use Hyatt Hy-Roll bearings. It's easy to design, quickly drawn and requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be pressed on the shaft . . . to become, for your purposes, virtually a part of the shaft. Since Hyatt Hy-Roll races are made from case-hardened, carburizing type steel, rather than through-hardened, they permit much heavier press fits without danger of cracking.

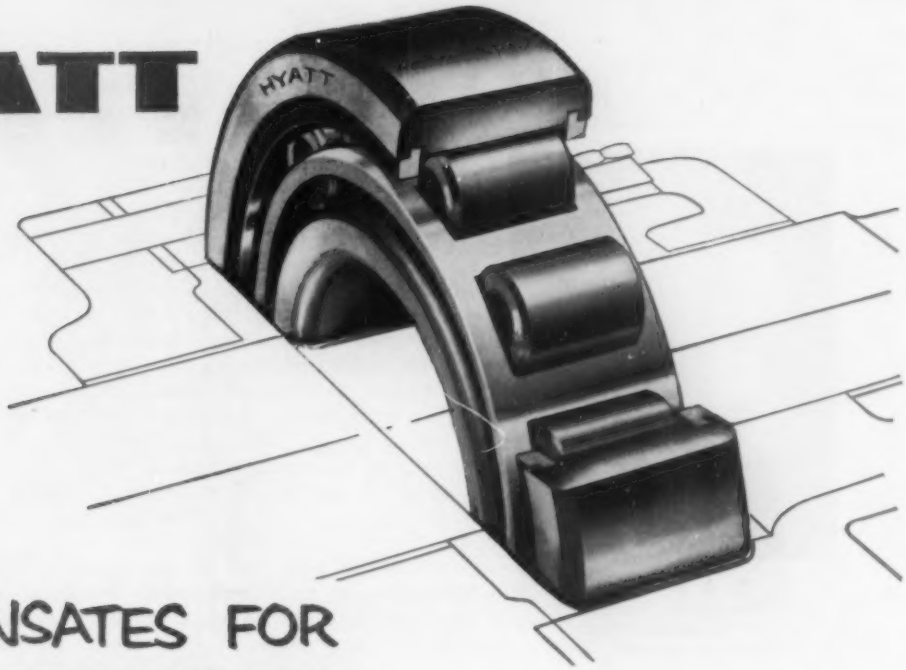
SAVE TIME

When equipment is being assembled you can see why Hyatt makes all separable races interchangeable within the same part number. It allows you to press an inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because with Hyatt Hy-Rolls selective fits are unnecessary. Think of the time it saves!





PROBLEMS ARE EASILY YOUR "SPECS" READ HYATT

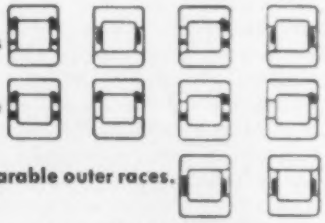


COMPENSATES FOR SHAFT EXPANSION

Heat can be a critical factor in the choice of a radial bearing. When the temperature rise causes lateral shaft expansion, it's safer to avoid laterally locked bearings. Used on a long shaft, they become misaligned, cramped, and overloaded when the shaft begins to heat up and expands laterally.

It's a problem you can avoid, very simply, with Hyatt Cylindrical Roller Bearings. In Hyatt's design, an extra length, separable inner race allows the shaft to float horizontally. This bearing compensates for lateral expansion, automatically, without changing the bearing centers and without depending upon uncertain float of a bearing loosely fitted in a housing. The usual practice is to hold one end of the shaft or roll while you allow "free lateral" at the other end by using a Hyatt Hy-Roll Bearing with a separable inner race.

Hyatt produces 10 major bearing types—four have separable inner races



—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

CIRCLE 23 ON READER SERVICE CARD 23

POINTS OF VIEW

THE QUESTION: *"In public affairs has*

Dr A B Kinzel
Vice-president, research
Union Carbide Corp
President, Engineers Joint Council

"Science cannot be overemphasized . . .
for it is the foundation on which technical progress is built. But the relation of science and engineering can be and often is misunderstood. In the general excitement about fusion, fission, transistors, fuel cells, microwaves, and outer space, the lay world has enthusiastically wrapped both science and engineering together and labeled it 'science.'

"The all too predictable results have been an uproar for more 'science' and 'scientists' and no clamor for engineers or engineering. The layman's inability to differentiate between the man who demonstrates the possibility and the man who provides the final structure has led to declined enrollment in undergraduate engineering courses and a regrettable lack of appointments of engineers to some governmental 'science' advisory committees.

"Fortunately within the technical world, the necessity for knowing 'How' as well as knowing 'Why' is well recognized and graduate enrollments in engineering are steadily increasing. However, as science and engineering continue to assume an even greater role in our political, economic, and social life, it is vital that the laymen have an increased understanding of the role of both the scientist and the engineer. Failure to recognize the importance of either will be detrimental to both. Neither science nor engineering can be overemphasized, but we of the technical world must make sure that those handling public affairs are sufficiently educated to keep the two in balance."

"A popular misconception . . .
of the nature of science and engineering is based on the impression that science is the center of attention in the American arena of research and development. Science is the understanding of man and the world he lives in; engineering is the use of this knowledge for the good of mankind. Popularly, achievements in advanced engineering are frequently identified as 'science' rather than as the sophisticated applications of scientific knowledge that they are—a tribute to the skill of the American engineer. This has been detrimental to both science and engineering and has contributed to the decrease in engineering enrollments in favor of science major. It has abetted the belief that science is well supported, whereas important areas of basic research remain seriously undernourished.

"The emphasis on science in national policy in recent years is a necessity because of our neglect of scientific research until after World War II. In the past, engineering has fared better in industrial and governmental support, being more immediately related to economic and military ends. While endeavoring to bring American science up to its full potential, increasing attention must and is being given at the national level to the problems of engineering. We need additional first-rate graduate schools in engineering. We need a new type of engineer trained to manage large, complex engineering enterprises.

"Policies designed to strengthen science will help strengthen engineering and vice versa. Just as nuclear power engineering began with the basic scientific discovery of nuclear fission, the scientific exploration of outer space depends on the engineering of large rocket boosters. Scientists and engineers should seek ways to reinforce their partnership and to draw into it social scientists to enhance further the richness and strength of American life. Let collaboration rather than competition be our keynote."

Dr George B Kistiakowsky
Special assistant to the President
for science and technology

science been overemphasized to the detriment of engineering?"

Dr Eric A Walker
President
Pennsylvania State University

"No and this is why . . .

Last year we spent about $10 billion for research and development here in America. But $600 million of this sum—only about 6% of it—was spent for basic research. This is not the arithmetic of an overemphasis on science. If it seems that science is receiving a disproportionate share of public attention, the engineers can blame only themselves.

"Engineering has become an important basic component of our total culture. This fact gives engineers and engineering a tremendous social responsibility—a responsibility for which they seem unprepared and which they seem reluctant to accept. Historically, engineers have prided themselves on their 'know-how' but have been content to let others make decisions and formulate policies. Calling themselves 'servants of society,' they have compiled brilliant records of achievement—in a society directed by lawyers, politicians, business executives and, more recently, scientists.

"With a 'how-to' orientation, that is exactly what engineers are, servants, in the basic sense of servile followers and laborers. But engineering has grown too important in our culture and our society for this sort of orientation. Today the engineer needs to become a full participating member of society—a member willing and able to assume leadership where he can lead more wisely than others. He must demonstrate his readiness to accept a leadership role commensurate with the importance of engineering as a social force.

"Until engineers accept this role, they will not be given the public attention that others receive. Policy makers, not mechanics or servants, dominate the headlines. Not until engineers lift their eyes from the drawing boards to look at the effects their designs and inventions have on the life of man—both as it is and as it could be—will they receive the attention that could—and should—be given them."

"One vital area of engineering suffers . . .

from a lack of emphasis but it is perhaps inaccurate to say that this is a consequence of too much emphasis put on science. The chain of events that starts with research and ends with hardware or a product includes three main steps. These are, in chronological order: research, advanced development, and project.

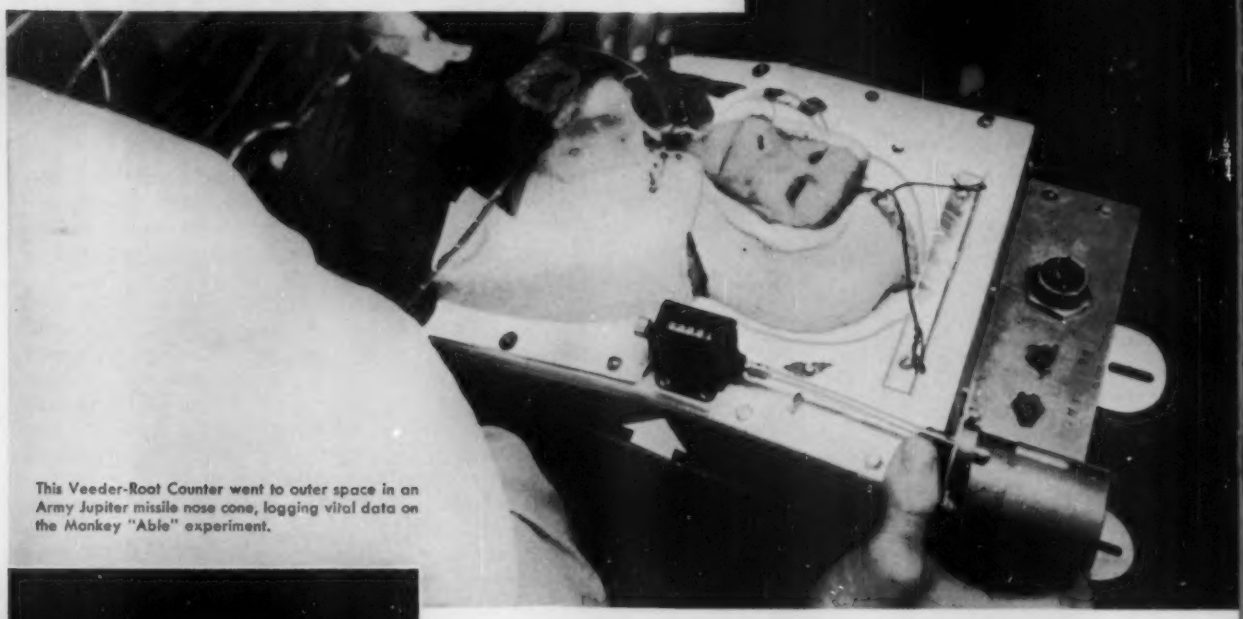
"Research is the area in which science finds new ideas and develops a basic understanding of natural phenomena. A subsection of this, of course, is applied science in which the goal of the research is clearly marked out. Advanced development is the area—essentially engineering in nature—in which the end-object is in sight in a vague form, but it is not yet known how to build it or make it work. This is the frontier of engineering, where new engineering ideas are developed. The final step is the project engineering which develops the end-object in conformity with knowledge built up in the preceding steps.

"It turns out that the costs of these steps goes up by at least one order of magnitude starting with research and ending with project, so that research is cheapest and project the most expensive.

"Currently there is a lack of understanding, reflected by too little funding, of the important engineering area of advanced development. There is a regrettable tendency to try to shortcut the intermediate steps and proceed directly from research to project engineering. More adequate funding and a more knowledgeable understanding of the importance of advanced development would result in a smoother and certainly less expensive transition from idea to hardware."

Dr William H Pickering
Director
California Institute of Technology
Jet Propulsion Laboratory

OPERATION READOUT — One of a Series

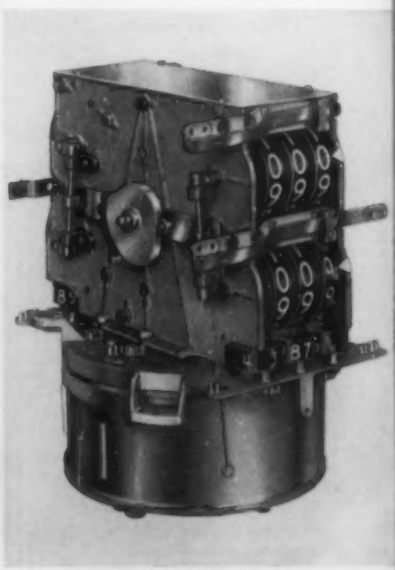


This Veeder-Root Counter went to outer space in an Army Jupiter missile nose cone, logging vital data on the Monkey "Able" experiment.

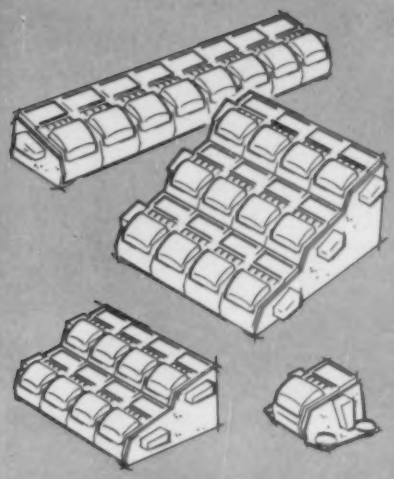
Everyone

Veeder-Root Counters used as Mileage Recorders provide control data for modern elevator operation. Information is used to plan preventative maintenance, and reduce downtime.

Veeder-Root Electromagnetic Counters give both a continuous and totalized report on tolerances, for this recently developed Taft-Peirce automatic gaging system. Eight different sets of dimensions are recorded.



The "Head for Figures" is this famous Veeder-Root Computing head for gasoline pumps, used the world over. It typifies advanced applications of readout and automatic control.



The Veeder-Root VARY-TALLY is a versatile, low-cost reset counter for faster, more accurate hand tallying. Provides positive, easy-to-read record of units, parts, inspection, paperwork, sampling. Available in single units, strips, tiers or any combination.

Counts on Veeder-Root

From outer space to the local gasoline pump, Veeder-Root helps communicate important information. How much? How often? When? How fast? Where? How long? Which direction? What position? . . . all these questions are answered easily, simply, quickly and directly through Veeder-Root's concept of digital communications . . . OPERATION READOUT.

Operation Readout helps you take full advantage of the newest and most advanced counting techniques. It is based on modern uses of Veeder-Root Counting devices, from the simplest type of ratchet counter to the most sophisticated designs of Remote Data Readout, Navigational Counters and Computer-Blender Pump Controls. Through these counters, digital communication and control can provide important advantages in speed, accuracy, human engineering, comprehension and operational control.

Veeder-Root Counters of the Month

New! 360° Tape-Type Bearing Counter was developed to provide digital readout of angular relationship. Tape greatly reduces size and weight over conventional devices. Adaptable to many indication requirements.

Series 1591 Quick Reset, High Speed Magnetic Counter is designed for accurate, dependable remote indication of machine operation, or for counting at high speed. Speed: 3000 cpm, 4 or 6 figures, manual or electrical reset.

Veeder-Root's "Operation Readout" can help you, now! Whatever your indication, readout or counting problem, Veeder-Root offers a century of experience in counting engineering. There are over 400 specific models in stock, ready for prompt shipment, or a special counting or readout device can be developed for your application. Contact your nearest Veeder-Root Counting Engineer or write direct.

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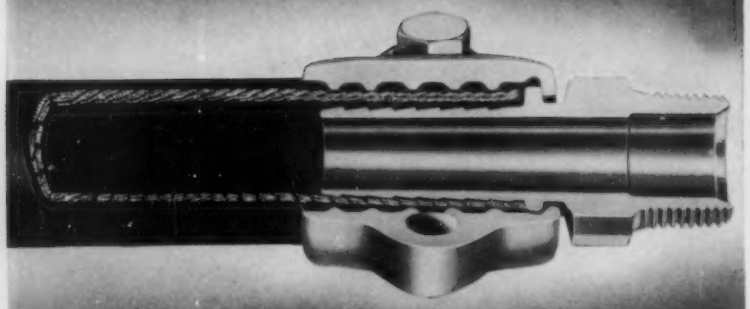

ANCHOR
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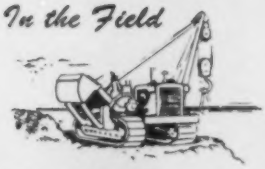
REUSABLE COUPLINGS
+
TWO AUTOMOTIVE TYPE WRENCHES
=
A QUICK, SURE, LEAKPROOF CONNECTION

In the Field



On the Road

In the Shop

Engineers and operators rely on these easily applied, streamlined Anchor Clamp-Type Couplings for fast, emergency repair and field service, as well as original equipment application.

Designed to accommodate normal variations in hose, they can be applied in the field with no tools other than a pair of automotive-type wrenches, and once applied, provide a sure, safe, leakproof connection that will remain intact up to the burst point of 2 and 3-wire braid hose.

Anchor Clamp-Type Reusable Couplings are supplied in high, medium or low pressure styles, for 3-Wire, 2 Heavy Wire, 2-Wire, 1-Wire, and Hi-Burst 2-Rayon Braid Hose, as well as Spiral Wire Suction Hose.

Write for Catalog No. 303.

Andy Anchor says:

"The Anchor representative who calls on you is a qualified specialist with years of experience in the hydraulic field. He will welcome an opportunity to help you with your hydraulic plumbing problems.

ANCHOR COUPLING CO. INC.

308 North Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

READER TO EDITOR

How to Give An Invention Away

To the Editor:

To begin with, a fellow could simply pass it along to one of his associates. This may be the fellow at the next machine, the next desk; or, he may contribute it to a neighbor he has invited over for the occasion.

There is one thing about this close-range giving that seems to be predominantly evident, however. Most of the folk on the receiving end don't seem to appreciate it very much. In fact, they seem to feel that they are doing you a distinct favor by taking the thing off your hands. They usually protest that the device won't work and that no one has any use for it, but they are humane enough to keep it. Later, they are humane enough to share it with the folks that need it if production is high enough and the price is right. Don't ever forget, however, that when you gave it to them, it wasn't the beautiful article that it is now. Before there were all kinds of loose ends. Why, the color scheme wasn't even two-toned. It was too heavy. And last, but not least, it was tied with a ribbon left over from last year.

Of course you can go a step further. You can give it to some of your commercial friends. They always appreciate something new. At this point, however, you have to pause to think what the word *new* means to them. Usually it means a different paint job, chrome plating, or boring out the cylinder another sixteenth of an inch. Of course, if your gift has a new approach, it will be taken very gingerly, for many liabilities are involved. It could upset management. It might cause confusion in the shops and, who knows? design might miss its deadline for the first time in 10 years. You can never tell just how far a bad idea will go, and an idea, gift-wrapped, may go even farther.

If you want to get real fancy, you get help from your legal section. For a fee they will determine the best dates to give, the prettiest stamps to use, and the proper color of ribbon. Of course, you should see your banker first about financial reserves, for this kind of giving may involve much more than you had expected. And it may mean that gifts are expected for a long time, too.

After you have taken care of your friends, your neighbors, your commercial friends, and the lawyer, there is only one other group that I would recommend giving very special treatment—the members of the high-high court. You have to give them a supreme treatment, my lawyer says. In the first place, not having a technical mind, they can't appreciate the gift so the wrapping has to be super duper. In the second place since most of them are discarded politicians, they are as sensitive as can be. Why, in 43 out of 44 cases they returned the gift to the inventor saying it wasn't really a new *gift* but that he had made it out of *existing materials* that any person competent in the field could have used. My old friend of 40 years' patent law experience says that

they are getting rougher all the time. He said Marconi couldn't give them the wireless today because he just organized a little gadgetry around his mother's doorbell. He said A. G. Bell would be in the same kind of trouble with the telephone because he had said that if he could just do two *simple little* things he could let people talk over wires. He doubts that Edison would get by with his light. And come to think of it, the wrapping wasn't anything to write home about.

—Howard R Johnson
Sorrels-Johnson Corp, Beverly, Mass.

Correction

To the Editor:

In your announcement of our new shock-resistant epoxy, HYSOL 6622-105 in Dec 7 '59, p 97, you stated that the material was particularly suitable for potting or casting large masses that cannot tolerate "heat curing" effects; it should have referred to "exothermic" effects.

—W C Jenner, *Manager*
Electrical Insulation Div
Hysol Corp, Olean, NY

COMING EVENTS

MARCH

15-17 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit.

23-25 . . . . Pressed Metal Institute, 1960 Spring Technical Meeting, Hotel Carter, Cleveland.

29-31 . . . . American Society of Mechanical Engineers, American Power Conference, Hotel Sherman, Chicago.

APRIL

5-14 . . . . International Spring Technical Fair, Utrecht, Netherlands.

4-8 . . . . Nuclear Congress and Exhibit, New York Coliseum, NYC.

5-8 . . . . Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, NYC.

6-8 . . . . Institute of Environmental Sciences, 1960 National Meeting, Biltmore Hotel, Los Angeles.

7-8 . . . . American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, NYC.

18-19 . . . . Joint Conference on Automatic Techniques, Sheraton Hotel, Cleveland.

19-21 . . . . American Society of Lubrication Engineers, Annual Meeting and Exhibit, Netherland-Hilton Hotel, Cincinnati.

20-22 . . . . Institute of Radio Engineers, 1960 Southwestern Conference and Electronics Show, Shamrock-Hilton Hotel, Houston.

CIRCLE 29 ON READER SERVICE CARD→

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Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

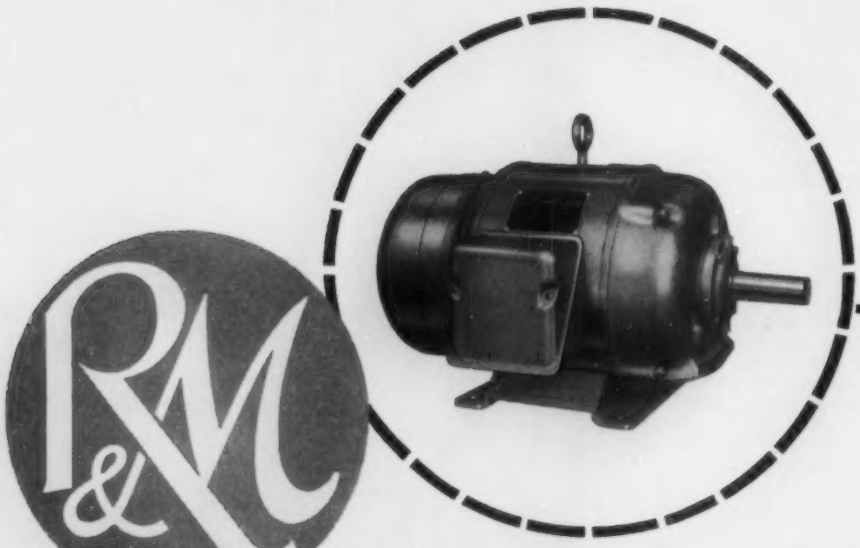
Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

THOMSON INDUSTRIES, Inc.
DEPT. 11, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting



Motors Thrive on FREQUENT OVERLOAD ABUSE!

***Brunswick* D-31 Precision Bowling Lane Sanders**

Powered by Lightweight R&M 8 HP Single Phase Motors

The Brunswick-Balke-Collender Company recently handed ROBBINS & MYERS an unusual motor problem when it re-powered the Brunswick D-31 precision bowling lane sander. The D-31 cuts across 250 square inches of area in one continuous cutting operation. Motor must withstand frequent and severe overloads when the machine levels high spots in the alley bed. Power had to be single-phase, too, because many bowling establishments carry only single phase current! To keep sander truly portable and easily maneuverable . . . and to protect lanes from excess weight, motor had to be lighter than ordinary single-phase motors.

ROBBINS & MYERS custom-designed an 8 HP capacitor-start, capacitor-run motor that is daily proving its stamina against these rugged requirements. Should more power be needed, design includes provision for adding an auxiliary blower which can conveniently increase capacity to 10 HP. Weight was kept down by using special aluminum end heads. For easier maintenance, the extended end-head housing can be removed quickly and easily to expose condensers and centrifugal switch.

Many other features insure longer life for *every* R&M motor: double width bearings that have extra-large grease capacity . . . Mylar* insulation with 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling.

For motors to meet unusual challenges . . . and for standard motors, always contact ROBBINS & MYERS! Write today for Bulletin 470PRE:

**DuPont registered trademark*

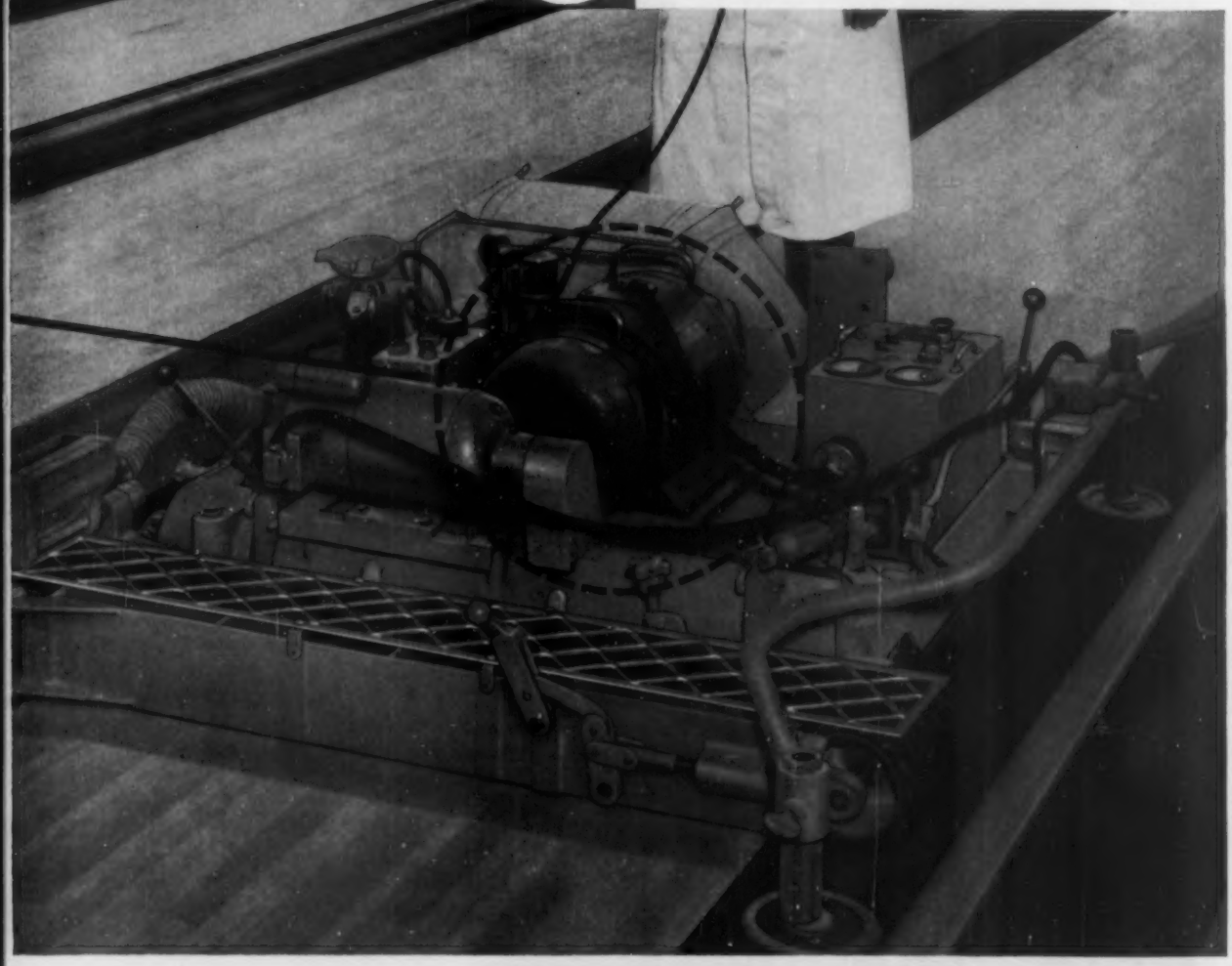
ROBBINS & MYERS, INC.

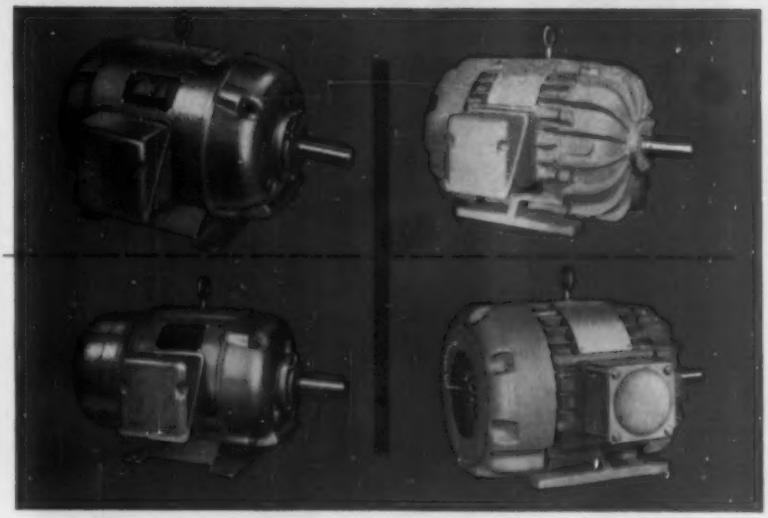
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)





Open Protected Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

CIRCLE 31 ON READER SERVICE CARD 31

The INSIDE INFORMATION

Here's literature prepared expressly for design men to simplify selection and application of the most appropriate molded packings for better product designs. These bulletins are packed with helpful charts, dimensions, diagrams, application drawings, recommendations and hints to save material and machining costs. They're yours for the asking—can help considerably in your quest for stepped-up product efficiency.

To help you keep abreast of up-to-the moment developments, trends, changes . . . write for your complimentary Palmetto Kit for Design Engineers.

ABOUT PALMETTO® MOLDED PACKINGS

The entire line is engineered for efficient utilization of space, material and cost. If you design-in molded packings for fluid powered equipment—you should specify and buy the proven performance Palmetto line.

PALMETTO G-T® RING — Effectively seals, without extrusion, at temperatures from —70 F to +600 F, and at pressures as high as 10,000 psi. Unique T-shape prevents wedging into clearances, pinch-offs under motion or pressure, or twisting in place. Absolutely resistant to destructive deformation.

PALMETTO PYRAMID® — An advanced form of V-rings, offered in two distinctive designs for broad hydraulic and pneumatic service. Sets of shallow Pyramid serve where packing space is limited; deep Pyramid sets are used where unusual sturdiness is necessary.

PALMETTO U-RING—Rugged, deep design increases stability, eliminates rolling in the groove. Excellent in low or high pressure cylinders—nominal or oversize bores.

PALMETTO KUP—An exceptional piston packing available in a variety of fabrications to seal the standard, or new synthetic fluids. More resistant to heat than leather . . . will not dry out and leak.

Whatever your sealing requirements—including diaphragms, Viton® molded parts, and other molded shapes — Palmetto engineers will work with you. Write today for your Palmetto Kit for Design Engineers — Feel free to call on Palmetto Design Service for assistance.

GREENE, TWEED & CO.
NORTH WALES, PA.

See us at Booth 336, Design Engineering Show, New York Coliseum, May 23-26.

32 CIRCLE 32 ON READER SERVICE CARD

FOR YOUR INFORMATION (personal)

New science of survival—It's Exobiology

The word may have an unfamiliar ring. But the field it covers is one that has long tantalized scientists, and someday it might prevent extermination of the earth's population.

Exobiology is the term now being applied to the study of the basic principles of biology and genetics as they pertain to the possible distribution of life in space. It is, in short, cosmic biology.

Its importance? First, to help us learn more about life and life processes.

Because utilization of water as a dispersing solvent, and the maintenance of temperatures in the 32 to 150-F range are fundamental to life on earth, we tend to assume that they are fundamental to life itself. But, as Joshua Lederberg of Stanford U School of Medicine warned the First International Space Science Symposium in France, "It would be incautious to reject the possibility of exotic forms of life that dispense with water, or thrive at temperatures well below zero." Furthermore, he notes, at least two of our sister planets may provide conditions well within the bounds of life as we know it.

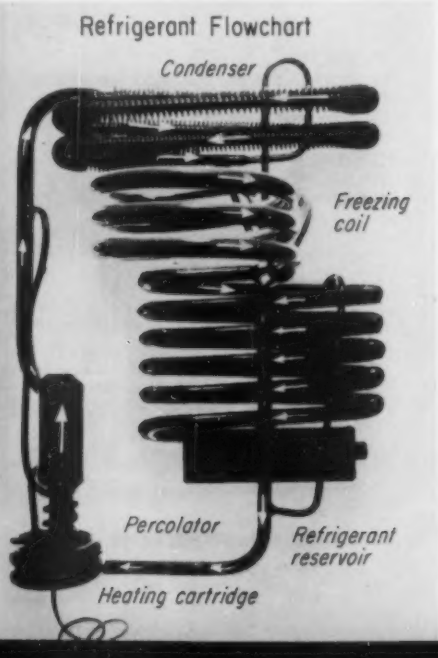
But there is another reason why we have to learn more about life in space —and learn it quickly. This, as Lederberg points out, is the possibility that there may exist, on other planets, organisms which could be dangerous to human life. "It is far more likely," he says, "that a foreign organism would be a mild nuisance than a dangerous parasite, but the stakes are too immense to allow us to temporize with any risk. . . . Until we have full knowledge of exobiota and of such properties as might make them either vulnerable or noxious, we can hardly risk any other policy but a strict interdiction on the return of any craft or material whatsoever from the habitable planets."

Watercooler looks same, works differently

A small watercooler that operates on the same principle as the big home-refrigerating units is being introduced by Arrowhead & Puritas Waters Inc, Los Angeles. The company believes it's the first electric watercooler to use the absorption method of refrigeration and says application of the principle makes it possible to offer the new unit at much lower cost than previous models. Wholesale price is $59.95; leasing cost, $2.90 per month.

The unit is less than a foot square, about 40 in. high, weighs 37 lb, will cool (to 50 F) about ½ gal. of water an hour.

The pictures show the unit as installed, and the refrigerant system which is barely 18 in. over-all height. —ARG



first in silicones

Dow Corning SILICONE NEWS

for design and development engineers • No. 72

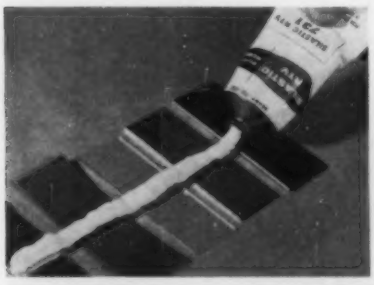
NEW AND HANDY

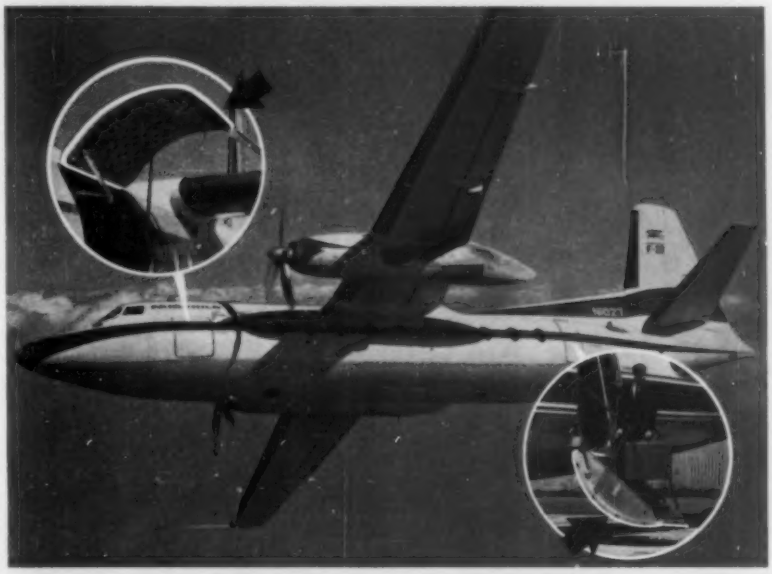
A new ready-to-use silicone rubber holds promise of high utility in a range of diverse applications.

Silastic® RTV 731, a single-component silicone rubber that cures at room temperature, is Dow Corning's newest addition to its series of silicone rubbers.

A unique advantage is that Silastic RTV 731 requires no catalyst premixing . . . can be applied easily from the tube that serves as an applicator or dispenser. Silastic RTV 731 provides excellent adhesion to most clean surfaces including metal, glass, ceramic, and plastic — adheres very well to laminates made with silicone resin or silicone rubber too.

Silastic RTV 731 needs only exposure to air to accomplish vulcanization, becomes tack-free within an hour, cures to a tough, rubbery solid in 24 hours. Applied to vertical surfaces, Silastic RTV 731 stays put—shows no tendency to sag, slump or flow prior to vulcanizing. (Cont. pg. 2)





SEALS BELOW 50 BELOW

Hot or cold . . . you can count on Silastic®, the Dow Corning silicone rubber, to maintain a positive, airtight seal. This fact helped designers at Fairchild Engine & Airplane Corp., Hagerstown, Maryland, handle a tricky gasketing problem on their new F-27 prop-jet transports.

Fairchild recently supplied a number of F-27B's to Northern Consolidated Airlines for service in northern Canada and Alaska. These craft were especially equipped with an oversize cargo door capable of admitting large heavy equipment for transportation into remote northern areas. Sealing the oversize cargo door, and the passenger door, too, might have been a real problem because of the bitter cold encountered by these aircraft at high altitudes . . . and ground temperatures often dip to 50 below zero! But, sealing was no problem at all . . . with gaskets made of Silastic. They never become hard and brittle, regardless of sharp temperature variations encountered in service.

The fact is that Silastic readily withstands prolonged exposure to temperatures as low as —130 F . . . or as high as 500 F. It retains an exceptionally high order of strength and resiliency, has a very low compression set, resists weathering, ozone, and corona . . . provides the ultimate in all-weather seal efficiency. *No. 241*

TYPICAL PROPERTIES OF SILASTIC FOR SEALS

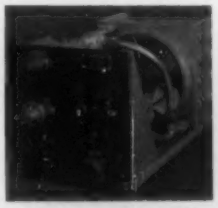
Temperature range °F	—130 to 500
Tensile strength, psi	600 to 1500
Elongation, %	150 to 400
Tear strength, lb/in	40 to 180
Compression set, %, @ 300 F	5 to 50
Hardness range, Durometer	25 to 80
Weather, ozone and corona resistance	Excellent

"COOL" COOLANT

The properties of silicone fluids have helped Hallicrafters Company design and produce lighter, less costly, more versatile heat exchangers for cooling airborne, shipboard and ground support electronic devices.

These highly efficient Hallicrafter units are offered in three standard models with ratings up to 7,000 watts dissipation. They are designed and produced to meet environmental conditions outlined in MIL-E-5272 and MIL-E-5400. All may be used with standard racks, and operate with maximum efficiency up to 70,000 feet at 71 C.

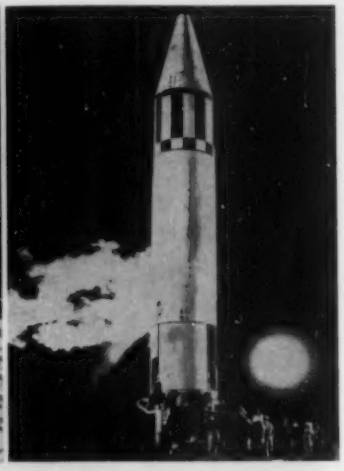
Among the properties that make Dow Corning silicone fluids ideal media for these heat exchangers are a unique relatively flat viscosity-temperature slope and a high degree of thermal stability and oxidation resistance. These semi-inorganic fluids maintain near constant viscosity over a range from —65 to 250 C. They can be pumped at high speed without suffering breakdown due to shear . . . pump easily at low temperatures . . . have good lubricity . . . won't vaporize at elevated temperatures . . . will not oxidize or corrode metals.



In sum, Dow Corning silicone fluids aid heat exchange units to operate uniformly and almost indefinitely, as far as the coolant is concerned. *No. 242*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



AID MISSILE RELIABILITY

Because they best withstand rigorous space age environments, silicone-glass laminates serve as terminal boards in the black boxes for the Jupiter missile's electronic control system.

Chrysler Corporation Missile Division engineers specified silicone-glass laminates for numerous uses throughout the electronic control system of the Army-developed Jupiter missile.

Here are reasons why: Extensive testing has proved that glass laminates made with Dow Corning silicone resin retain excellent dielectric properties in spite of heat, moisture, environmental aging, rapidly changing ambients, vibration and shock. In service, silicone-glass laminates have excellent resistance to ozone, arcing and corona; in storage, to fungus attack. Glass laminates made with Dow Corning Silicones are designed to meet MIL-P-997B, are highly reliable dielectrics for all units subject to adverse environments, serve well even when exposed to high humidity and high voltage conditions.

Other advantages: Silicone-glass laminates are easy to work with, fabricate and assemble; have good physical properties; show excellent resistance to creep under pressure; aid production schedules because soldering heat doesn't loosen terminals while wiring is secured. *No. 243*

NEW AND HANDY *(Continued)*

The properties of Silastic RTV 731 point to its practicality in many applications similar to those of presently available room temperature vulcanizing silicone rubbers . . . and in numerous new applications, too . . . with the advantages of greater ease of application and better, stronger bond to practically all surfaces.

Sample tubes of Silastic RTV 731 may be obtained for evaluation in your application. Request sample on company letterhead, addressing Dept. . . . . *No. 244*

TYPICAL PROPERTIES OF SILASTIC RTV 731 AFTER VULCANIZING 24 HOURS AT 77 F

Color	White
Brittle Point, degrees F	−100
Volume Coefficient of Thermal Expansion	9.3×10^{-4}
Thermal Conductivity, cal per cm (degrees C.) (sec.)	0.495×10^{-3}
† Durometer Hardness, Shore A Scale	25
† Tensile Strength, psi	200
† Elongation, percent	250
Serviceable Temperature Range, continuous	−70 to 300 F
short term	to 500 F

† After vulcanizing for 24 hours at 77 F in 1/8" thick cross section.

new literature and technical data on silicones

TACKLES MANY JOBS — An article reprinted from **Power** tells how silicone insulation has proved to be a useful asset in most every type of electrical equipment ranging from dry type transformers to wire and cable. Exceptional thermal endurance and stability of insulation made with Dow Corning silicones have spurred its use in today's electrical equipment, as evidenced by subjects covered in this article. *No. 245*

DON'T MISS THEM at the IRE show in New York, March 21 thru 24. Dow Corning booths No. 4103 and No. 4105 will be filled with displays of silicone materials that help electronic units operate reliably — even in the toughest environments. If you can't be there, get information now about these aids to better electronic design. *No. 246*

UP-TO-THE-MINUTE. The new **Engineering Guide to the Properties and Applications for Dow Corning Silicone Products** is now available. This 16-page brochure contains the most current information on all lines, all forms of silicone products manufactured by Dow Corning for engineering applications. Bring your reference files up-to-date by encircling. *No. 247*

SEA HUNT — Fine performance of sonar transducers and similar underwater electronic devices depends largely on fluids with uniform sound transmission characteristics. Dow Corning 220 Fluid, developed especially for use as a sound transducer fluid, provides many desirable properties including heat stability, near-uniform viscosity over a wide temperature span, oxidation resistance and good electrical properties. *No. 248*

NEW ADHESIVE — Silastic Adhesive 140, the ready-to-use adhesive that sets up at room temperature, provides an excellent means of bonding air-vulcanized and/or oven-cured silicone rubber to itself, to metals, to glass, or to a variety of organic rubbers and plastics. The data sheet on this new product details properties of Silastic Adhesive 140, and cites bond strengths between different combinations. A valuable new product for consideration. *No. 249*

Dow Corning Corporation, Dept. 8603 Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248 249

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TITLE _____

COMPANY _____

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SILICONE NEWS is published for design and development engineers by

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motors like these help your product STAY AHEAD of competition...

Lamb® series motor with two-stage fan — the standard for high performance domestic canister-type cleaners.

Lamb® three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader. Frame 4⅜ x 2¼.

Lamb® induction gearmotor with special quiet operating three-stage gear train and magnetic brake for rotary office file. Frame 4½ x 2⅜.

Lamb® four-pole split phase motor with resilient cradle base for business machines. Frame 4½ x 2¼.

Lamb® six-pole 400cycleACmotor for operation submerged in jet fuel for booster pump drive. Frame 2⅞ x 2½.

Lamb Electric works in so many fields — where motors that have vastly different jobs to do are sold to vastly different markets — that experience gained in one field often helps solve problems in other fields.

For example, we are able to incorporate in motors for appliances, portable electric tools, and similar products, developments that came about in research and engineering work on military and other precision motors.

This broad experience — available to all of our customers — is one way in which Lamb Electric special application motors can help your product stay ahead of competition.

Let us demonstrate the value of this experience in bringing to *your customers* improved products and to *you* more business and better profits.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

WRITE FOR YOUR COPY

8-page folder describes these and other Lamb Electric motors.

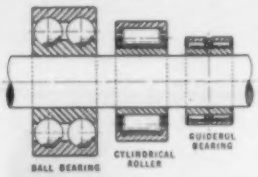
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

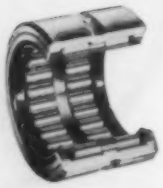
McGILL®

GUIDEROL® bearings offer higher load

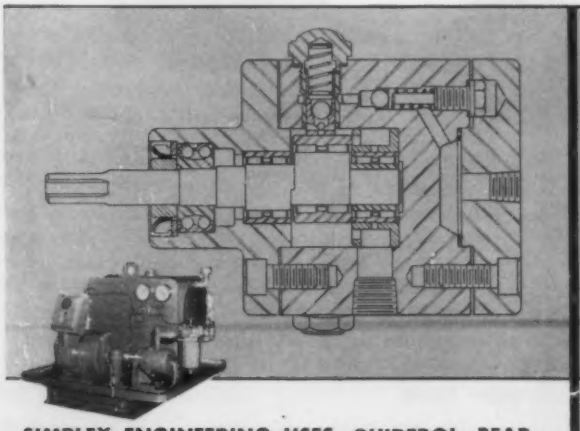
GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1" shaft, the GUIDEROL bearing has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅝" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance



Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

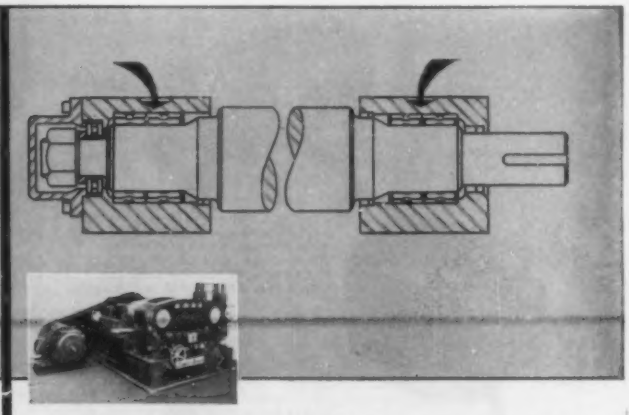


SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

MCGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of MCGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1" thick by 8" wide.

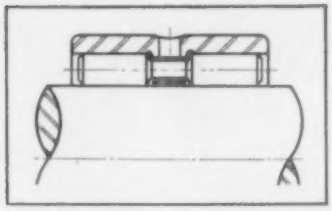
Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

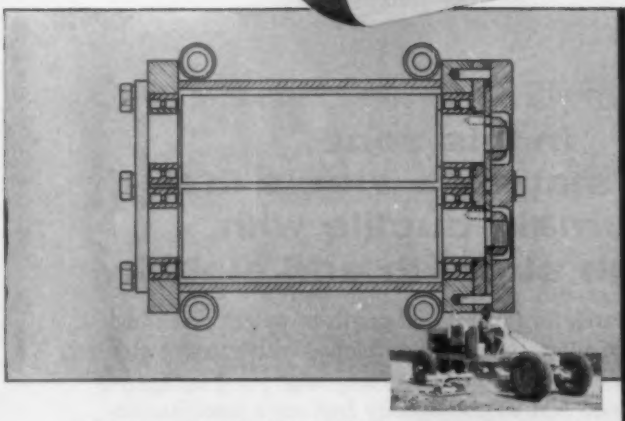
Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

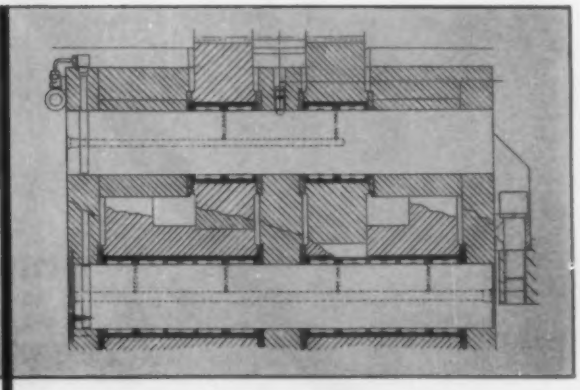
WRITE TODAY FOR FREE McGILL BEARING CATALOG No. 52-A for complete data on McGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

capacity in smaller radial space

GUIDEROL BEARING
Cutaway to show center guided roller principle







GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.

GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products

McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Div.,
201 N. Lafayette St., Valparaiso, Ind.

CIRCLE 37 ON READER SERVICE CARD 37

in this zone, stainless steels that remain ductile with high strength and stability

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1000 F, but at the expense of ductility.

In AM 350 and AM 355, Allegheny Ludlum's precipitation hardening stainless steels, you have high hardness and stability from room temperature to 1000 F, plus almost twice the ductility!

These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.**

661

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

H. P. Lockhart, Assistant General Manager Sales, Austin-Western, Construction Equipment Division, Baldwin-Lima-Hamilton, Aurora, Ill.

"On-the-job reports prove that IH power is an excellent choice for our hydraulic crane."

International UD-282 diesel shown here is interchangeable dimensionally with UB-264 gasoline engine.

Customer's job records show INTERNATIONAL® Power ideal for AUSTIN-WESTERN Crane

For their heavy-duty hydraulic crane Austin-Western engineers specified a rugged industrial-type engine, in the 80-90 horsepower class, that would provide dependable power for the boom hoist, yet would operate smoothly and economically at road travel speeds. International UD-282 and UB-264 engines exactly met these requirements and were dimensionally interchangeable. And they gave the customer a choice of either gasoline or diesel fuel. Reports from users show that Austin-Western cranes equipped with International engines are doing outstanding jobs.

When designing your products it will pay you to check International's line-up of diesel and carbureted engines. You will find the rugged carbureted models and instant-start diesels are interchangeable in power and dimensions. And IH power flexibility provides efficient operation through wide variations in load and speed.

Investigate the many advantages available to you by powering your products with International. You have a choice of 32 engines from 16.8 to 385 max. hp, a size to fit any power requirement. For detailed information call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL® ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

CIRCLE 39 ON READER SERVICE CARD

ENGINEERED PRODUCTS

for
Hydraulic-Pneumatic
Service

TOP EFFICIENCY WHERE FLUID POWER IS INVOLVED

Garlock Leather Cups actually tend to polish metal surfaces they contact. Provide good resistance to abrasion and wear . . . unmatched for tensile strength and toughness . . . low coefficient of friction, minimum cold flow. All sizes, shapes, designs available for wide variety of pressures, temperatures, non-caustic fluids. For more severe service conditions, rubber fabric-inserted cups are generally recommended. Catalog AD-145.

Garlock CHEVRON* Packings are as close to "frictionless" as you'll find. As pressures increase, the packing rings tighten to prevent leakage; with declining pressures, the rings ease off, permitting free operation of the rod, ram, or piston without leakage. Once installed, need no further adjustment to meet pressure variations. Available in many materials, including Teflon† for practically all applications. Catalog AD-115.

CHEMISEAL* Nylon Pressure Tubing by Garlock is the ideal answer for hydraulic and pneumatic lubrication, oil, and fuel lines and vacuum system connections. It resists fatigue, abrasion, impact . . . withstands temperatures from −60° F to +180° F and higher. 1000 and 2500 psi grades available, conforming to J.I.C. specs. You can flex it or bend it for greater design freedom, versatility. Catalog AD-171.

GARLOCK

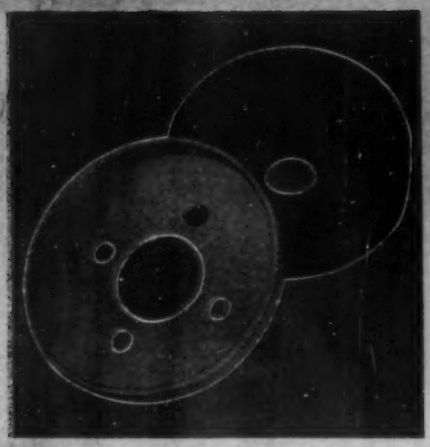
Take advantage of this "know-how" in the design field. Talk to your local Garlock representative at the nearest of our 26 sales offices and warehouses throughout the U.S. and Canada. Or, write The Garlock Packing Company, Palmyra, N.Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

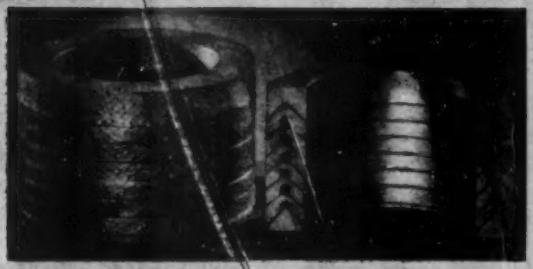
Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

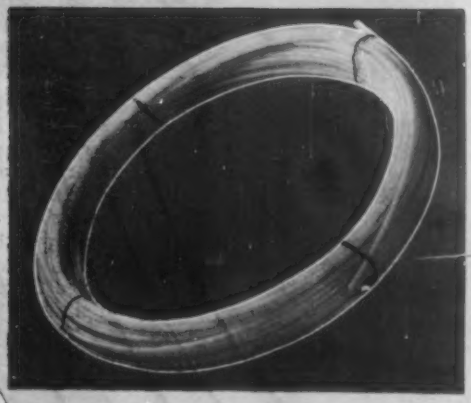
*Registered Trademark
†DuPont Trademark



LEATHER CUPS are naturally tougher than other materials . . . suitable for most applications. Fabric cups are recommended for severe service.



CHEVRON PACKINGS permit free operation with minimum friction at all pressures . . . last longer, need less maintenance.



CHEMISEAL NYLON PRESSURE TUBING is unaffected by solutions which corrode metal . . . costs less than metal . . . available from ⅛" O.D. up.

Specify your construction requirements, we can create an ideal tailor-made answer in STAFOAM.

This foamed urethane miracle material is as versatile as the human imagination. Rigid or flexible, film-thin or wall-thick, STAFOAM mixes strength and lightness in unusual proportions; resists ozone, weather, time; fabricates easily.

Apply STAFOAM in its many varied forms to build, insulate, pad, reinforce, package or filter... to cushion, dampen, float, or protect.

Behind STAFOAM and its limitless applications are the Freedlander Laboratories—the nation's largest institution devoted to urethane research and development. Years of specialization of polyurethanes, extensive modern facilities, and an outstanding record of problem-solving are at your disposal when you consider STAFOAM as a possible answer to your construction needs.

For a new dimension in material technology, contact the Freedlander R & D Laboratories, American Latex Products Corp., or its branches. Specify product requirements and/or material category.

stafoam.

HEADQUARTERS FOR NEW IDEAS

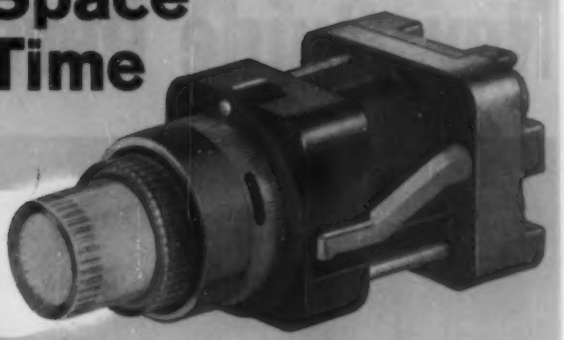
made by AMERICAN LATEX PRODUCTS CORPORATION, Hawthorne, Calif. and the parent company, THE DAYTON RUBBER COMPANY, Dayton, Ohio

AMERICAN LATEX BRANCHES:

SAN FRANCISCO	SEATTLE	DALLAS	HOUSTON	OMAHA
42 Gough St.	2231 5th Ave.	1300 Crampton St.	401 Velasco	3304 N. 48th Ave.

...design leadership

Save Mounting Space and Installation Time *with this...*



ILLUMINATED PUSH BUTTON

- Push button and pilot light combined in one compact, oil-tight device
- Full heavy-duty contact rating
- Pressure connections eliminate internal wires
- Clearly marked terminals for easy wiring
- Button guard available to prevent accidental operation
- Full range of voltage ratings
- Choice of 6 color caps
- Same single-hole mounting as other oil-tight units

A *Complete* LINE OF OIL-TIGHT CONTROL UNITS

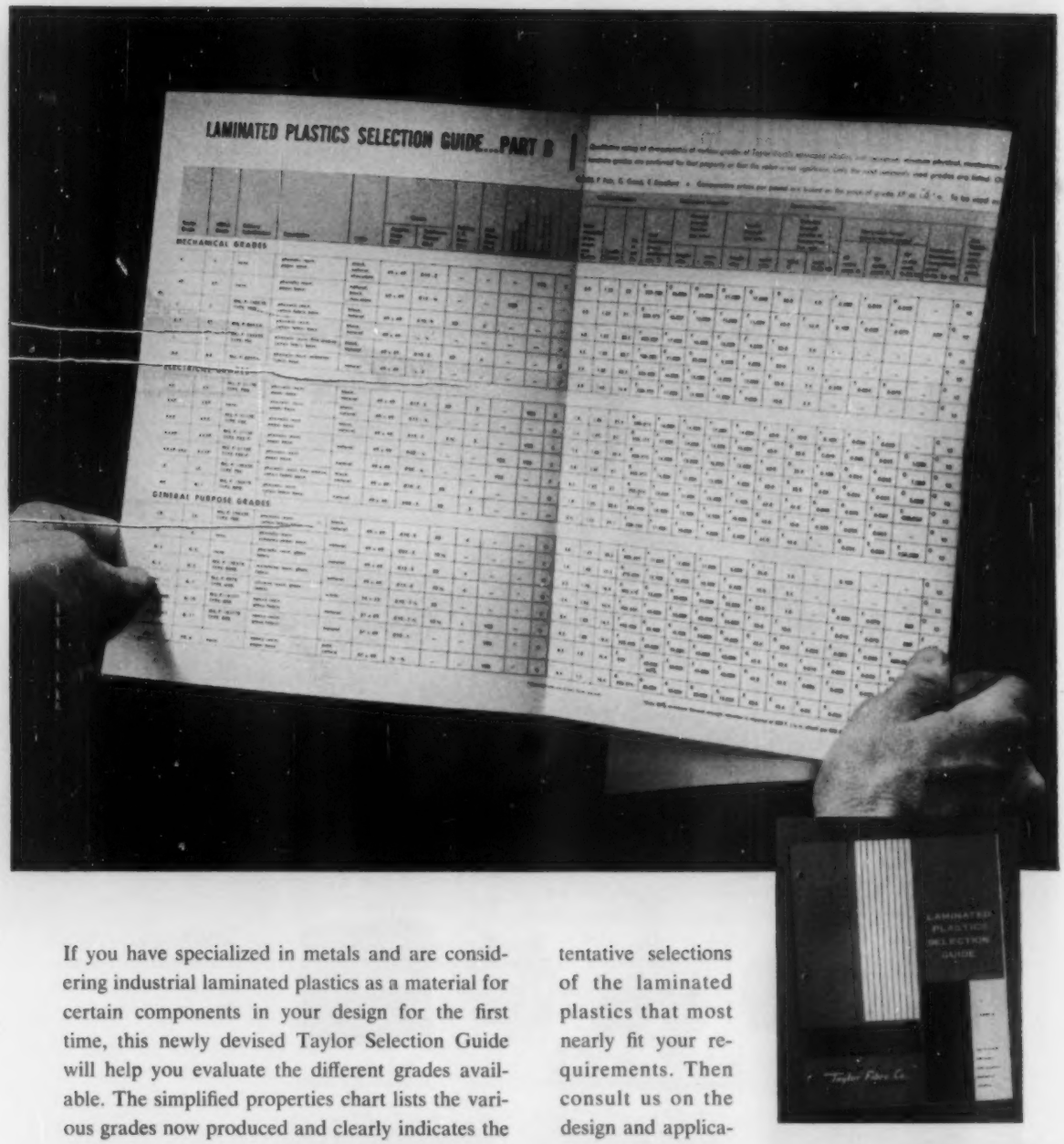
Write for Bulletin 9001-T
Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

wherever electricity is distributed and controlled

Important facts to know about laminated plastics

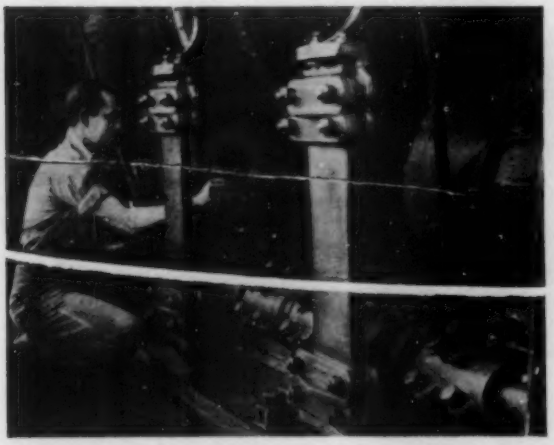
New Guide Developed by Taylor



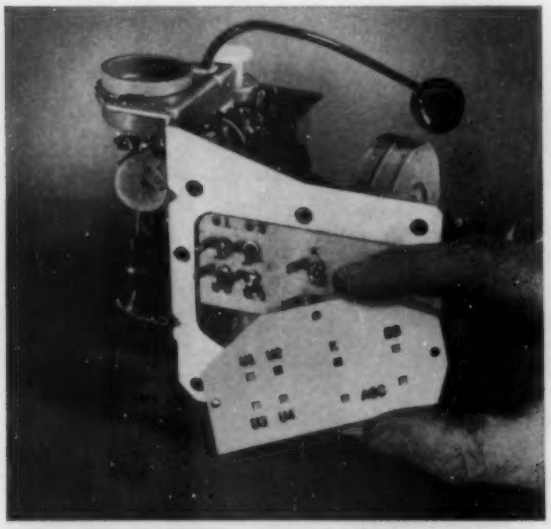
If you have specialized in metals and are considering industrial laminated plastics as a material for certain components in your design for the first time, this newly devised Taylor Selection Guide will help you evaluate the different grades available. The simplified properties chart lists the various grades now produced and clearly indicates the properties in which they excel. An accompanying booklet gives helpful hints on the selection of laminated plastics for your specific application. Write for your copy of this handy Taylor Laminated Plastics Selection Guide today. Use it to make tentative selections of the laminated plastics that most nearly fit your requirements. Then consult us on the design and application of laminated plastics and parts fabricated from them before making a final decision. Our application engineers will be glad to discuss them with you. Write Taylor Fibre Co., Norristown 39, Pa.

Simplifies Laminate Selection

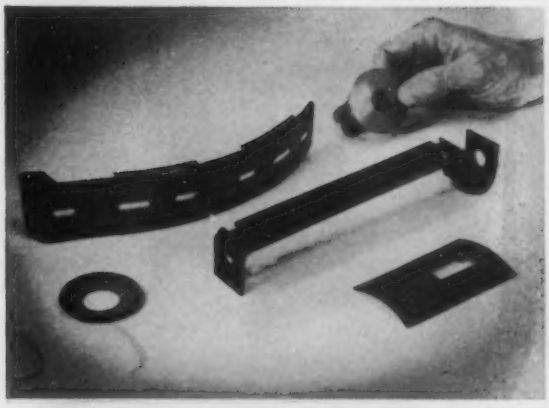
Suggested applications of different grades of Taylor Laminated Plastics



For the fabrication of springs, silent gears, pinions, cams and bearings: Taylor Grade C—a phenolic resin, cotton fabric base, mechanical grade and Taylor Grade L, a phenolic resin, fine weave cotton fabric base grade.



For high-temperature electrical applications and high-frequency radio equipment: Taylor Grade GSC—a silicone resin, glass fabric base, high-heat-resistant electro-mechanical grade.



For forming into intricate shapes, compound curves, and deep draws: Taylor Grade C-7—a phenolic resin, cotton fabric base, postforming grade. Also Taylor XX-7—a phenolic resin, paper-base postforming grade.

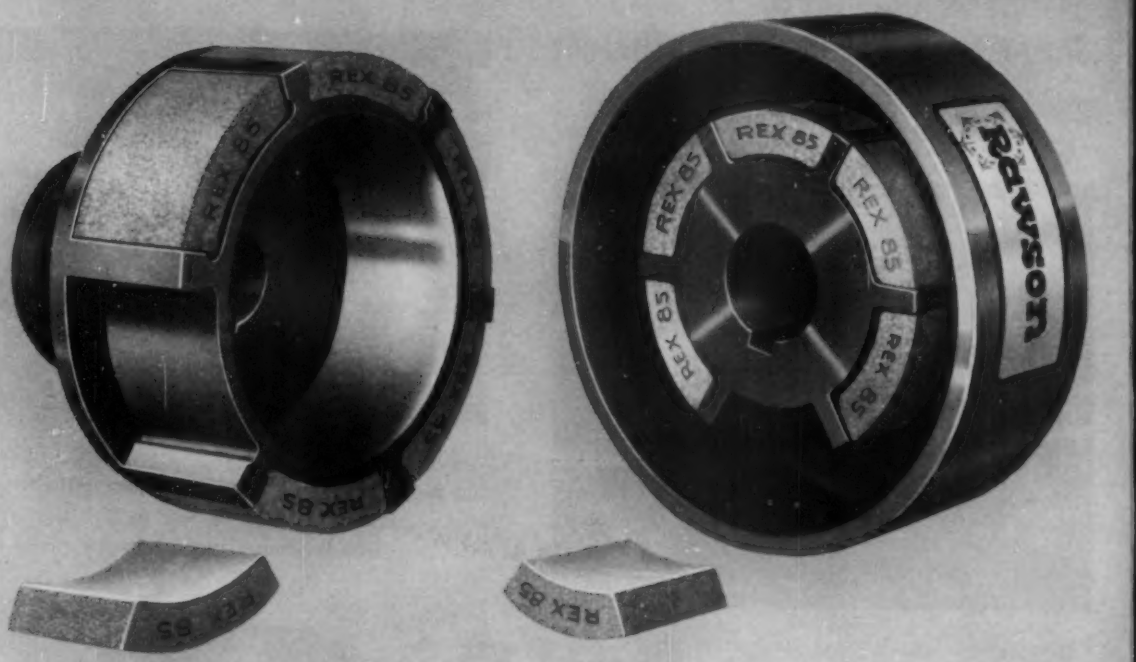
For applications requiring high-strength retention at elevated temperatures: Taylor Grade GEC—an epoxy resin, glass-fabric base grade.

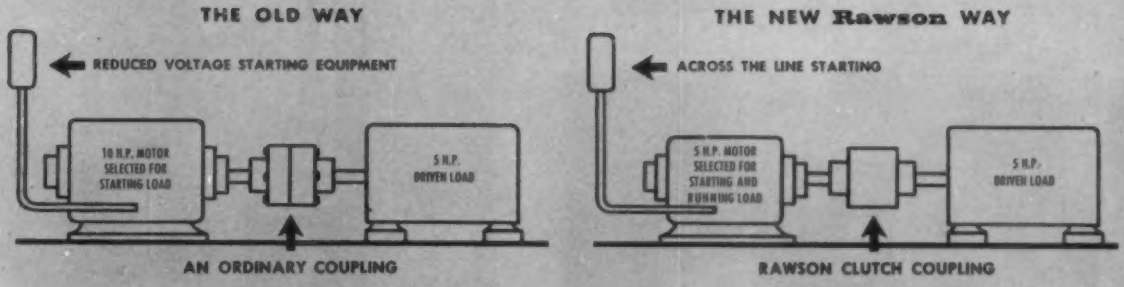
Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

CIRCLE 45 ON READER SERVICE CARD 45

NOW! You Can Use Smaller Motors Improve Motor Performance




THE OLD WAY
REDUCED VOLTAGE STARTING EQUIPMENT
10 H.P. MOTOR SELECTED FOR STARTING LOAD
5 H.P. DRIVEN LOAD
AN ORDINARY COUPLING
THE NEW Rawson WAY
ACROSS THE LINE STARTING
5 H.P. MOTOR SELECTED FOR STARTING AND RUNNING LOAD
5 H.P. DRIVEN LOAD
RAWSON CLUTCH COUPLING

Check These Additional Features of

- Exclusive all-metal shoes permit higher operating temperatures, assure longer life.
- For power applications up to 2,000 horsepower, drive in either direction.
- Fluid-smooth starting without the power loss of fluid types at full load R.P.M.
- Protects the most delicate equipment by eliminating starting shock.
- No dangerous prolonged surge current when high-inertia equipment is started.
- All-metal shoes never need adjusting, entirely mechanical operation assures longer life.

. . . Lower Starting Equipment Costs . . .

. . . Secure Automatic Overload Protection

With Rawson Centrifugal Clutches

The Rawson is an all-metal centrifugal clutch that drives in either direction and provides: *no-load* starts for motors—cushioned starting of equipment at predetermined R.P.M.—automatic overload protection—slip-free power at normal operating speeds—rugged design for applications up to 2,000 horsepower.

Results: "no-load" starting decreases acceleration time and starting current—across-the-line starting can be used instead of costly reduced voltage equipment—based on lower starting load, smaller motors can often be employed—cushioned starting of high inertia loads frequently permits using NEMA B or standard squirrel-cage motors instead of expensive special high-torque motors—delicate equipment is protected by eliminating starting shock—jamming or overloading of driven equipment will cause the clutch to slip, providing protection for motor.

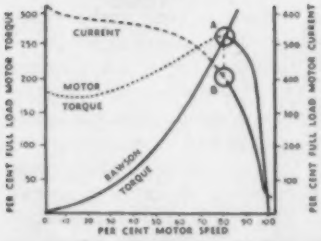
Rawson clutches function as direct-drive clutch-couplings (in-line, shaft-to-shaft connection) or as indirect-drive clutches through V-belts, chains or gearing. They can be furnished with delayed engagement for standby or dual drive installations.

Rawson clutches are simple in design, they never require adjustment, and are entirely mechanical in operation for trouble-free performance. For higher efficiency, lower costs, reduced maintenance and full protection for even the most delicate equipment, specify Rawson centrifugal clutches and clutch-couplings.

Ask your Rawson distributor or write directly to us for your free copy of Rawson Catalog No. 141.

FORMSPRAG COMPANY
23607 Hoover Road, Dept. 109
Warren (Detroit), Michigan

FORMSPRAG COMPANY

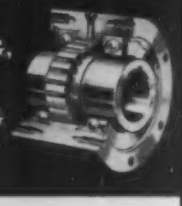


Typical torque and current characteristics of a standard NEMA B motor. Because Rawson clutch does not fully engage until after peak torque speed "A" is reached, motor acceleration time is much faster, peak current period is greatly decreased and motor operates more efficiently "B". Thus, smaller motors and across-the-line starting can be used.

Rawson Clutches

- **No-load starting reduces motor acceleration time to a fraction of a second.**
- **Full power at normal operating R.P.M.—No Slip, No Power Loss, No Heat.**
- **Rugged design and all-metal construction keep maintenance requirements to a minimum.**

THERE IS A FORMSPRAG OVER-RUNNING CLUTCH FOR EVERY OVER-RUNNING, INDEXING & BACKSTOPPING APPLICATION



Modern Formsprag over-running clutches are universally used by automotive, aircraft and other industries. They provide greatest torque for size and weight, higher precision and no measurable backlash. Torque capacities range from 50 lbs. in. to 136,500 lbs. ft. Standard bore sizes from ¼" to 12". Our engineering department will design special Formsprag clutches for your unusual applications. Write for your copy of Formsprag catalog.

CIRCLE 47 ON READER SERVICE CARD

THIS IS DU PONT DELRIN®

a new engineering material offering the user distinct performance and cost advantages in many applications once reserved for metals

The three new products on the opposite page typify the performance and cost advantages that "Delrin" acetal resin offers over die-cast zinc and aluminum, cast and machined brass, stainless steel and cast iron.

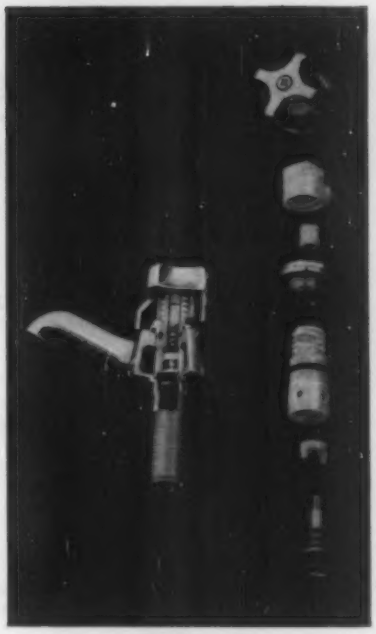
Ronson, for example, has reduced a part's weight by 80%... Kel-Win cut production costs by 80% ... Lionel saves on assembly with a one-piece coupler design.

This ability of "Delrin" to perform in many areas once reserved for metals stems from its unique combination of properties. "Delrin" has the stiffness to remain rigid in large sections, the tensile and flexural strength to withstand high-stress loadings, the dimensional stability to hold close tolerances and the abrasion resistance to operate usually without lubrication. "Delrin" retains these properties even under exposure to wide variations in temperature, humidity, solvents and stress.

"Delrin" also offers the user the economies of production via injection molding and extrusion—processes that can usually reduce costs by eliminating all finishing operations. Part-to-part uniformity minimizes rejects. To simplify assembly, parts may be joined by mechanical fasteners, spin welding, snap and interference fits or often designed as multi-function, integral units. Varied surface effects are achieved by texturing, vacuum metalizing, painting or molding in color.

We will welcome the opportunity to assist you in evaluating how "Delrin" can help you improve a product, lower its cost or develop new designs for your profit. A letter or the enclosed coupon will bring a prompt reply.

The head frame (top) of the new "Lady Ronson" Superbe electric shaver is molded of "Delrin", saving 80% of the weight of the previous goldplated die-cast zinc part. Ronson Electric Shaver Corp., Stamford, Conn., specified "Delrin" because only it could be molded to and hold the necessary dimensions, have a smooth luster without finishing and resist body oils and colognes.

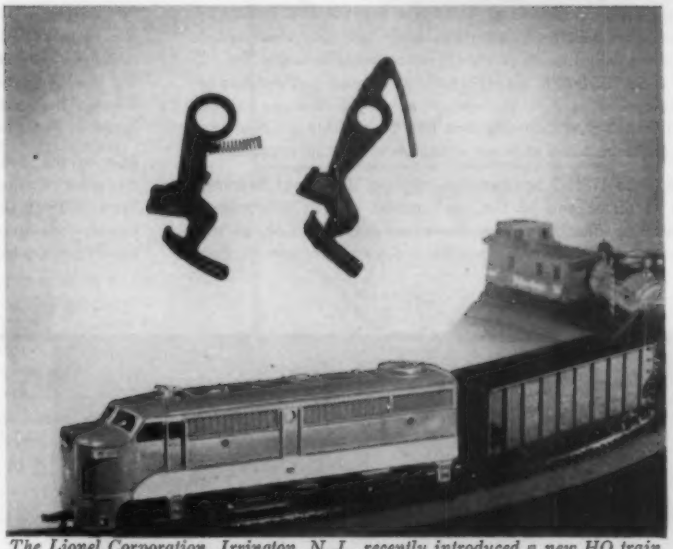


Four parts (in white) of this self-seating faucet are molded of "Delrin", saving 80% of the cost of the machined brass components formerly used by the Kel-Win Manufacturing Co., Inc., Richmond, Va. Kel-Win chose "Delrin" because only it resists corrosion and mineral buildup, remains dimensionally stable and keeps handles comfortable to the touch. Cost savings accrue from the elimination of machining operations and rejects. (Molded by Dominion Plastics Co., Colonial Heights, Va.)

THIS IS WHAT DELRIN® IS DOING

With commercial production of "Delrin" a reality, hundreds of manufacturers are now producing or have specified "Delrin" for such uses as: gears, bearings, housings, aerosol bottles, clothing fitments, pump and valve parts, conveyor belt plates and a host of mechanical components. Three products are described here.

The broad range of the 500 applications of "Delrin" tested during the past three years prompts our belief that "Delrin" may well be profitably used in the products you make or use. Commercial processors and our own staff of technologists are ready to assist you.



The Lionel Corporation, Irvington, N.J., recently introduced a new HO train line featuring a one-piece coupler molded of "Delrin". Because "Delrin" has the resilience to provide the desired springing action, Lionel designed the integral unit to replace a two-part assembly of coupler and coil spring. The result: a significant assembly saving plus a new sales feature. "Delrin" is also used for the axles, journals and two other truck parts. (Molded by Lionel and Gries Reproducer Corp., New Rochelle, N. Y.)

FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON...

E. I. du Pont de Nemours & Co. (Inc.) Dept. II-314
Rm. 2507D, Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

_____

NAME_____

COMPANY_____ POSITION_____

STREET_____

CITY_____ STATE_____

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec

POLYCHEMICALS DEPARTMENT

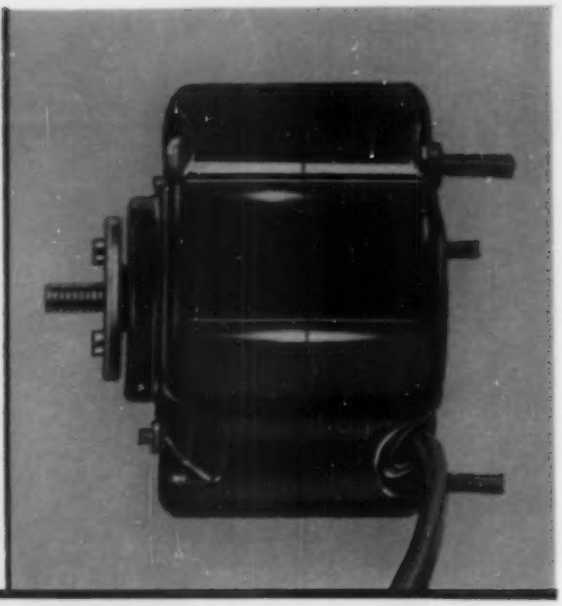
DU PONT

REG. U.S. PAT. OFF

Better Things for Better Living . . . *through Chemistry*

NEW DUAL-BEARING UNIVERSAL MOTOR

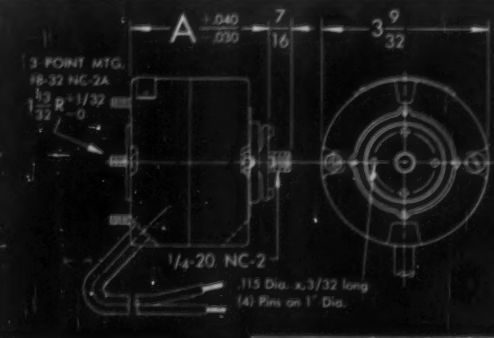
provides dependability and long life in Refrigeration Fan Applications



The Type 118H-3, shaded-pole hubless fan-motor is a rugged, new, precision built motor that has been specially designed to precisely meet the needs of refrigeration manufacturers. The 115 volt-60 cycle-1550 RPM model is totally enclosed and suitable for all angle operation. It conforms to all existing dimensions and has the standard 3-stud mounting and the 4-pin hubless adapter so that it can be installed as original equipment without modification.

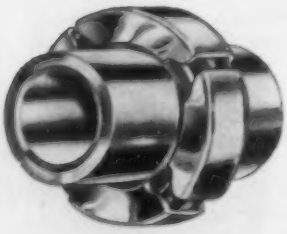
This new Type 118H-3 has two *free-aligning* **Universal Bearings** located at either end of the shaft rather than a conventional single bearing. These bearings are of an advanced design and eliminate fractional HP motor problems due to misalignment. Each has its axis of support at the center, rather than at the end; they are therefore always in balance and adjust themselves to shaft misalignment under any load conditions. This results in longer bearing life and assures a motor that is efficient, sure starting and quieter. These bearings are self-lubricating and each one incorporates an extra large, life-time oil reservoir.

Due to the two *free-aligning* **Universal Bearings**, the newly designed laminations and the improved rotor construction, the Type 118H-3 Universal Motor will provide years of reliable, trouble-free operation. Special windings are available on request; write for complete information.



115 Volt—60 Cycle—1550 RPM
"Universal Bearing"
All Angle Operation
High Impedance Protected
Totally Enclosed
No Oiling Required
Special Windings on Request
Rotation Determined Viewing Shaft End

Watts Output	Amps.	A
4	.42	2.442
6	.45	2.817
9	.50	2.817
12	.60	3.317



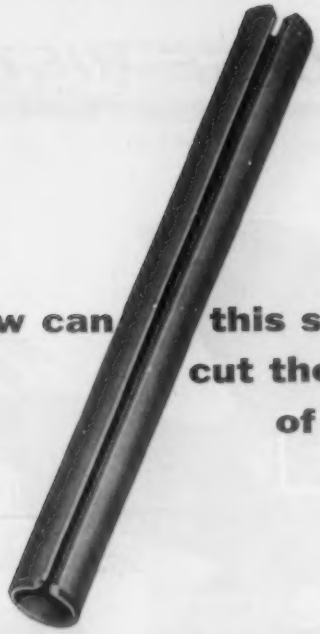
New Universal Bearing has support pressure on center of bearing rather than the end to eliminate uneven tension and permit adjustment of axis position to *true* alignment. Neoprene collar around outside surface of bearing accommodates manufacturing tolerances; small metal clips confine collar, allow free sliding movement along bearing support surface.

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

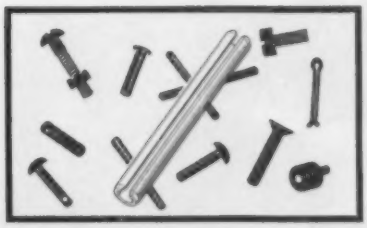
54



How can this simple fastener cut the cost of your product?

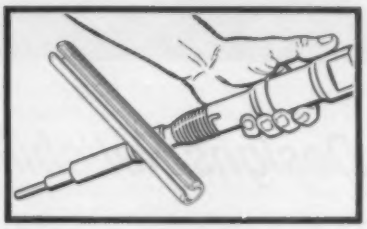
Rollpin aids standardization and reduces inventory

Rollpin readily replaces taper pins, grooved pins, straight pins and set screws; it can be used as a locating dowel, hinge pin, cotter pin, stop pin or, in some applications, even as a rivet. Thus, when you standardize on a Rollpin you can drastically reduce the variety of fasteners in your inventory—save money in purchasing, storage space and stock handling.



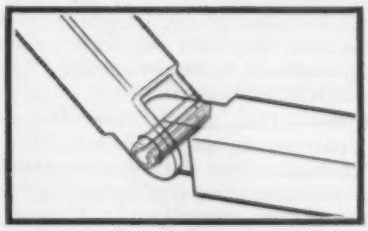
Rollpin simplifies production processing . . . saves man-hours

When you use Rollpin you can eliminate costly precision drilling, or tapping operations. And there's no need for any secondary locking operation—such as lock wiring or peening. That's because Rollpin is a slotted tubular steel spring whose chamfered ends drive easily into standard production-drilled holes, compressing as driven. The spring tension against the hole walls retains Rollpins securely against severe vibration. Independent studies have shown that installed costs of Rollpin are as much as *91% less* than those for a dowel pin or *95% less* than the installed cost of a taper pin.



Rollpin simplifies product maintenance

Only a drift pin or standard punch is required to remove a Rollpin. The slotted tubular shape and the spring action principle do not damage hole walls or enlarge the original hole diameter. Consequently the same pin is easily re-inserted and can be used again and again. Mail our coupon today for the complete Rollpin story.



ROLLPIN®

a product of
Elastic Stop Nut Corporation of America

Dept. R-58-345, Elastic Stop Nut
Corporation of America
2330 Vauxhall Road
Union, New Jersey

Please send the following free fastening information

- ☐ Rollpin bulletin
- ☐ ELASTIC STOP® nut bulletin
- ☐ Here is a sketch of a fastening problem. What ESNA® fastener would you recommend?

Name_____

Title_____

Firm_____

Street_____

City_____ Zone____ State_____

CASE HISTORIES

N/D integral rolleron gyro wheel and shaft with precision instrument ball bearing solves sidewinder reliability problem. Actual ball bearing O.D. measures little more than an inch.

N/D Designs Reliability Into Sidewinder Rollerons!

CUSTOMER PROBLEM:
With ever-increasing speeds of new fighter aircraft, the rollerons of this aircraft-fired missile failed because they were subjected to environmental conditions more severe than those for which originally designed.

SOLUTION:
New Departure engineers in conjunction with Naval Ordnance Test Station solved the problem by recommending a simplification of the original rolleron assembly. An integral gyro wheel and shaft was designed that maintains critical rolleron reliability. What's more, the new design reduces inventories, assembly time and inspections. And today, this same N/D creative engineering and reliability can be found in more than twenty of America's major missiles . . . in airframe, guidance, propulsion and ground support.

If *your* product has unusual ball bearing demands, call in a New Department Sales Engineer. He's armed with a complete line of Miniature, Instrument and standard ball bearings . . . one that's sure to do the job for you! Write Dept. L.S., New Departure Division, General Motors Corporation, Bristol, Conn.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

March 14, 1960

THE REAL JOKER

In medieval times and earlier, each king or chief had his jester who was supposed to be funny on order. Indications are that many of these so-called fools were extremely clever fellows—cleverer by far than their lords—or they'd never have kept their caps and bells.

Something of the same sort is happening nowadays. Each plant, each company, has its R & D department, expected to produce developments for new products on order. This is harder than it sounds, and not nearly as foolish.

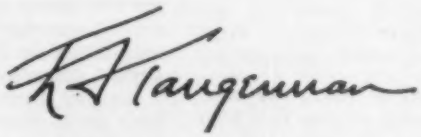
Our tremendous recent advances are apparently in the nuclear, missile and space areas—it's from them that most of the publicity emanates. In actuality, our economy is advancing because of thousands of less-publicized developments, because of thousands of products now available that weren't even heard of a decade ago. The "big push" results from growth industries like titanium sponge, transistors and transducers; servo-mechanisms like power steering and brakes; TV sets; plastics like polyethylene, styrene and synthetic fibers and rubber; electrical appliances like can openers, hair dryers, coffee makers, shavers, air conditioners, stereo tape recorders; power tools like lawnmowers, hay balers; and chemicals like the antibiotics. No single one can claim the credit; these are just the fastest-growing fields among dozens. But note that every one resulted from research, most of it intentional.

This is a phenomenon of our time—planned and organized research rather than the hit-or-miss approach of the old-time lone inventor. The phenomenon is made even more phenomenal by the billions of dollars being poured in each year. Some of it will inevitably go down the drain, but some will contribute to an increasing flood of new products, new processes, new materials.

Some older products will die as a result of it, too. Each has its life span, just as people do, but in recent years, that life span has been shortening while that of people has been lengthening. While the products listed above have been burgeoning, others have been steadily declining: railroad passenger cars, local transit units, cast iron boilers, heating stoves, radiators, even those familiar basic materials, lead and tin.

Thus we enter the Soaring Sixties, with major dependence on research for company futures. But it isn't enough to set up R & D and assign it money; paradoxically, it must be fed ideas. Recent studies indicate that only two of ten new ideas come from Engineering, while five come from Sales and Marketing. Men in the field discover the need, while R & D and Design go on to develop a product to meet the need. Indications are, too, that Marketing often is the moving force behind the extension of parameters—many sales are of products not yet developed.

That's where R & D resembles the court jester most—it must meet the Sales Department's idea of how good it is. And that's the real joker.



COORS PRECISION CERAMIC PART ENDS CORROSION OF PRESSURE SWITCH

Ceramic valve for respirator so sensitive it can be actuated by infant's breath

Bird Oxygen Breathing Equipment, Inc., of Palm Springs and San Francisco, manufactures a new, compact, precision respirator used by anesthesiologists in delicate surgical procedures and by physicians to treat lung diseases like asthma and emphysema.

Operation of the instrument is dependent upon the extreme sensitivity of a pressure switch . . . a switch so sensitive that the slightest intake of breath causes the respirator to operate and begin breathing for the patient . . . so sensitive that it operates from the breath of a weakened patient, even a new-born infant. The respirator must be able to work perfectly even after years of disuse on the shelf, under conditions of sporadic operation, and under conditions of regular exposure to oxygen, ozone and moisture.

Metal and alloy parts corrode. With every metal or alloy that Bird designers tried as parts for the pressure switch valve, the minute amount of moisture present in the gases used caused an electrolytic action that resulted in adhesion of the metal plunger to the sleeve—a slight seizing, but enough to prevent the valve from operating with the necessary sensitivity. Oxidation was also a problem—the slightest roughening of the smooth surfaces prevented valve from functioning.

Coors Ceramic valve eliminates corrosion. These problems with metal valves were eliminated when Bird used Coors High Strength Alumina Ceramic (type AD-85) in place of metals. Because Coors ceramics do not corrode or seize, and because properly finished ceramic surfaces have a very low coefficient of friction, the pressure switch works perfectly. Also, because of the extreme hardness of the Coors Ceramic, there is little or no wear—the precise fit of the ceramic plunger and sleeve is retained throughout the operating life of the respirator, tested to 20-million cycles of perfect operation!

During manufacture of the ceramic parts, Coors holds tolerances to 0.000025" on both the O.D. of the shaft and the I.D. of the sleeve. Difference in diameters between shaft and sleeve is held to 0.0001-0.0003".

Coors High Alumina Ceramic is a fine engineering material for applications requiring a high degree of corrosion resistance or abrasion resistance . . . also for applications that require high strength under conditions of extreme heat . . . or for any combination of these conditions.

Coors Complete Engineering Service. Coors offers a complete field engineering service to assist you in utilizing these high strength ceramics to the best advantage. **Write for complete Technical Data Sheets on Coors Ceramics and facilities.** The following Coors Sales Engineers are ready to help you with your current ceramic problems:

REGIONAL SALES MANAGERS

West Coast.....William S. Smith, Jr.
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Southwest.....Ken Lundy
RI 1-5225 – Dallas, Texas

Oil Industry Applications....William Ramsey
UN 4-6369 – Houston, Texas

Midwest.....John E. Marozeck
FR 2-7100 – Chicago, Ill.

Central.....Donald Dobbins
GL 4-9638 – Canton, Ohio

East Coast.....John J. McManus
MA 7-3996 – Manhassett, N. Y.

New England and New York.....Warren G. McDonald
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Coors

COORS PORCELAIN COMPANY

600 Ninth Street, Golden, Colorado

TECHNICIANS—answer to the SHORTAGE of ENGINEERS

who are these institute graduates?
how well are they trained?
where do you find them?
what jobs can they handle?

G ROSS HENNINGER, *director*
ASEE National Survey of Technical Institute Education, and
President, Ohio College of Applied Science and Ohio Mechanical Institute

It's not a shortage at all, says the author. The real need is for engineering technicians—they'll free design engineers for more creative chores. But that calls for training many thousands more of these useful middlemen between engineers and skilled mechanics.

Unquestionably, there is a need for more engineering personnel in the United States today. But what kind of personnel? That the acute shortage occurs, not in the area of graduate engineers and scientists, but rather in the area of competent supporting personnel is becoming more generally understood. We know now that a tremendous increase is necessary in quantity and percentage of competently prepared graduate engineering technicians.

The "engineering team" is a term that applies to a working relationship between the engineer or scientist, the engineering technician, and the skilled mechanic or industrial technician. The ratio of one to the other may grow to be as high as 150 skilled mechanics to 10 engineering technicians to 1 professional engineer or scientist.

For effective use of this team we must speed the trend

←CIRCLE 54 ON READER SERVICE CARD

toward more rational concepts and a better balance and coordination in our national education pattern.

First, we don't need more and bigger engineering colleges but we do need better ones doing a more discriminating, penetrating, and stimulating job in challenging the nation's best young brainpower.

Second, we need more and better qualified technical institutes to take up where the engineering college leaves off—aimed at large segments of students heretofore served through traditional channels of engineering education. Technical-institute education must be an inseparable part of higher education.

Third, we need more and much better technical high-schools and technical vocational schools to take up where the technical institute leaves off. The concept of the "area vocational school" as embraced by the National Defense Education Act of 1958 falls squarely in this category. Above all, this part of secondary school education must be lifted out of the unfortunate category into which it has been placed—that of a combination of correctional institution for academic recalcitrants and repository for social misfits. This school must raise the academic discipline of its program to inspire and train the 150 skilled mechanics needed for each engineering team.

Manipulative skills and aptitude for them are nothing to be ashamed about—even in education. Think of how people fawn over the manipulative skill which is used to produce music from a grand piano. Why should there be less recognition for the highly skilled fingers that create the physical needs of mankind?

Just What Are Engineering Technicians?

The National Survey of Technical Institute Education, a two-year study sponsored by the Technical Institute Division of American Society for Engineering Education, gives the following definition:

> Engineering Technician is a graduate of a technical institute with a curriculum (about two years' full time) accredited by Engineers' Council for Professional Development, or recognized equivalent. He performs semi-professional functions of engineering or scientific nature, largely upon his own initiative and under only general supervision of professional engineer or scientist whom he assists. The engineering technician's chief interests and activities are in testing and development, application, and operation of engineering and scientific equipment and processes.

Today, too many graduate engineers have to do the work of engineering technicians. These engineers can and must be used to the utmost of their creative capabilities; they must not be chained to routine jobs more economically accomplished by engineering technicians who can be trained in two years in a technical institute.

Where Do You Find Them?

Engineering technicians are graduates from a technical institute (Ohio College of Applied Science is one of many examples) or from technical institute programs under university surveillance, such as Georgia Institute of Technology, Oklahoma State University, University of Dayton, and the University of Houston, all of which conduct the programs on their main campuses. Purdue University,

ENGINEERING

Typical 2-year Courses Offered by

Electrical (power*)

FIRST TERM
- Algebra and Trigonometry I
- English I (written and oral)
- Physics I
- Engineering Drawing I
- Dc Circuits
- Dc Machinery
- General Psychology I

SECOND TERM
- Algebra and Trigonometry II
- English II (written and oral)
- Physics II
- Mechanical Processes and Equipment
- Electrical Drafting
- Ac Circuits
- General Psychology II

THIRD TERM
- Introductory Calculus
- Machine Processes I
- Electronic Drafting
- Electronics I
- Ac Machinery
- Chemistry I

FOURTH TERM
- Calculus
- Industrial Psychology
- Thermodynamics
- Strength of Materials
- Electronics II
- Electrical Design I
- Chemistry II

FIFTH TERM
- Statistical Mathematics
- Industrial Management
- Heating and Air Conditioning
- Electrical Controls
- Electronic Systems
- Power Systems
- Electrical Design II

* *Also available is electronics option which includes courses in TV Studio Operation, FCC Preparation, Electronic Lab Techniques, Special Tubes and Circuits, Semiconductors, Video Equipment and Operation*

TECHNOLOGIES

Ohio College of Applied Science

Mechanical

FIRST TERM
- Algebra and Trigonometry I
- English I (written and oral)
- Physics I
- Engineering Drawing I
- Mechanical Processes and Equipment
- Electricity (Dc circuits)
- General Psychology I

SECOND TERM
- Algebra and Trigonometry II
- English II (written and oral)
- Physics II
- Manufacturing Processes and Materials
- Engineering Drawing II
- Electricity (Dc Machines)
- Chemistry I
- Physical Metallurgy
- General Psychology II

THIRD TERM
- Introductory Calculus
- Tool Design I
- Machine Processes I
- Strength of Materials I
- Mechanism
- Electricity (Ac Circuits)
- Chemistry II

FOURTH TERM
- Calculus
- Industrial Psychology
- Machine Processes II
- Thermodynamics I
- Strength of Materials II
- Machine Design I
- Electricity (Ac Machines)

FIFTH TERM (Heat Power Option)
- Statistical Mathematics
- Industrial Management
- Heating and Air Conditioning
- Thermodynamics II
- Internal Combustion Engines
- Gas Turbines
- Machine Design II (theory)
- Heat Power Systems Design

FIFTH TERM (Design Option)
- Statistical Mathematics
- Industrial Management
- Thermodynamics II
- Internal Combustion Engines
- Gas Turbines
- Tool Design II
- Machine Design II (theory)
- Machine Design II (lab)

Pennsylvania State University, and the State University of New York conduct their programs through a statewide system of campuses. The University of North Carolina has recently placed in operation the first unit of a proposed statewide system of technical institutes.

Many junior and community colleges are potential sources of engineering technicians. Most, however, are dedicated to or preoccupied with preparatory programs designed for college transfer, and these are preponderantly in the field of liberal arts or "general" subjects.

How Are They Educated?

The idea of technical-institute education must be approached as a philosophy, rather than an institution. Basic objective is to develop a qualified engineering technician, proficient in a preselected field of technology. In general, the objective is accomplished within two academic years, with an Associate Degree awarded upon completion.

The technical-institute program is not intended as a feeder channel to the university. The program is not the equivalent of the first two years of the university four-year engineering course. It is much more than that in some important aspects, somewhat less in others. Its direction and emphasis are significantly different. Take a look at some typical curricula on these two pages and compare it with your own first two years.

Unfortunately, the two technical-institute years are commonly referred to as a "terminal" program. Many qualified people shy away from such a program, mistakenly and to their personal loss. The technical-institute program is no more "terminal" than any other college-degree program. It is "terminal" only in not being specifically designed to meet the limiting requirements characteristic of most college and university catalogs for transfer credits. The bona fide technical-institute program is designed instead to give the student a high degree of proficiency in a preselected field of technology, solidly supported by a sound working knowledge of the mathematics, English, basic science, and technological principles needed in that field.

Philosophy of this institute idea in higher education is that for every young person with the capacity and incentive to pursue formal technological education through to advanced college degrees, there are many who have the capacity, interest, and aptitude to develop more productive and rewarding careers in the expanding fields of applied science and technology—which neither require nor justify four or more years of college study.

The term "technical-institute education" refers to the intermediate strata of technical curricula which now are becoming settled at two years' duration (full-time) beyond the highschool level. Curricula are technical in nature, and they differ in both context and purpose from those of the vocational school on one hand, and from those of the engineering college on the other.

Curricula emphasize understanding and practical application of basic principles of mathematics and science, rather than the acquisition of proficiency in manual skills. Highschool graduation is required for admission, and mathematics through algebra and geometry are prerequisite.

Programs of instruction are similar in nature to professional engineering curricula, but briefer and more com-

pletely technical. The major purpose is to prepare individuals for specialized technical positions.

What Role Do They Play?

Place of the qualified technician is well established and growing—across the whole spectrum of professional, technical and business enterprise. It is neither new, nor peculiar to engineering. To consider the proper place of the technical-institute program in the national educational and professional spectrum, you must realize that it is the engineering field which has "exploded."

As the results of scientific research complicate the tasks of the engineer and carry his field farther away from the realms of application and operation in which modern engineering started and grew, two facts stand out with increasing clarity.

First, some adequate and integrated provision must be made to continue to supply technically competent manpower for this engineering application and operation, and also to augment and supplement the professional engineer and scientist in research, design, development, and supervision. This manpower is a part of the over-all engineering-manpower spectrum. In general, it is taking the place of the "engineer" as we have known him in the past—the "engineer" of today and tomorrow increasingly takes his new place and becomes more and more devoted to the scientific problems and opportunities of the expanding technological universe.

Second, the educational program for the engineering technician must be intimately related to that of the engineer, yet must be significantly different. In contrast to the engineer, the technician does not need the depth nor the extent of mathematical or scientific understanding. However, he does need a practical working understanding of essentially the same subject matter, together with appropriate communication skills and mathematical competence. To achieve the necessary results, the education must be comparable in quality and general level to the university-college engineering program, but different in that the emphasis must be on practical application of established scientific principles rather than the development of new design concepts or the extension of existing knowledge.

Why the Shortage?

The shortage of engineering technicians arises principally from a lack of understanding among educators, the technological professions, industry, and the general public. Result is that many young people are diverted from entering technical-institute programs because highschool teachers and parents advise almost everyone of average ability or better to seek admission to a university. Teachers are familiar with recognized professions, but have little knowledge of industry. Parents are inclined to regard a four-year college degree as a hallmark of social success. This inclination is not discouraged by most of the four-year colleges, junior colleges, and "preparatory" schools. For example, two universities offer certain curricular programs falling well within the "technical institute" definition of the survey and of the ECPD specification, yet both declined to participate in the survey and objected to their offerings being considered as technical-institute programs.

Another aspect of the status problem is that there is no generally accepted pattern of professional recognition for engineering technicians. In this respect the medical technician, dental technician, and various other comparable technicians in business and professional fields are much better off.

In American industry only a relatively small number of firms thoroughly understand the technical-institute idea, and integrate the engineering technician into their force of technological manpower.

Confusion in terminology is probably the leading cause of the lack of understanding. The word technician means different things to different people, both in industry and in education. Within industry there is extensive confusion with respect to the engineering technician as defined. Much of this confusion arose through the chain of circumstances wherein industry, needing more technological manpower than was available through the combined output of technical institutes and engineering colleges, has provided its own technicians by establishing and operating many internal training programs.

When industry comes to realize that there is a function being performed, for the most part by engineers, that could be performed by two-year graduates of engineering technical institutes, then will there be a great demand for engineering technicians. When this happens, many of the problems of status, confusion, etc., will disappear, and many, many engineers will be released from routine jobs to do the more creative work for which they were trained.

ENGINEERS MOVE INTO SCIENCE

Our editorial (PE—Feb 1, p 37) discusses inter-relationship of science and engineering this way:

"Not too long ago the two were distinct fields, one grown out of theory, the other out of practice . . . Now they are growing closer together—engineering is hard on the heels of science with products that stretch available scientific knowledge to the utmost . . . Many R & D teams include both scientists and engineers . . . Science and engineering are becoming integrated and are accelerating the pace of their advances."

Author Henninger suggests engineering technicians to fill the growing gap between the purely intellectual or professional areas and the area of manual skills.

EDITOR'S NOTE: For other ideas on reducing the shortage of engineers, see:

The Engineering Debate . . . Has Capitalism Failed? March 9 '59, p 45. Asserts that two major problems exist in engineering education: institutional support (money), and lack of appeal to superior young people.

Next Design Project? . . . Engineering Curricula, Nov 17 '58, p 35. Suggests reorganization of engineering education. Offers 3-part program (2, 4, and 7 years) with each part distinct and separate.

Can We Get More Engineering Per Engineer? Sep 21 '59, p 32. Describes new techniques and equipment designed to reduce noncreative load on engineers.

Engineering Colleges Revamp Courses to Emphasize Science, Aug 31 '59, p 19. News story tells how leading engineering schools are strengthening their curricula to meet realities of present-day engineering and summarizes freshmen enrollments since 1950.

PRODUCT ENGINEERING SPECIAL REPORT

DESIGN GUIDE... WHEN YOU NEED

NONCIRCULAR GEARS

Gears in this category are not new — but generally are not understood, or employed very frequently. Yet they offer distinct advantages over linkages and cams. Here's a discussion of most types of noncircular gears — also equations and tables giving their basic characteristics, and three design problems putting the equations to work.

B. BLOOMFIELD, computer division
The Fellows Gear Shaper Co.

The popularity of noncircular gears has grown steadily in recent years mainly because of their usefulness in mechanical computing devices. Previously, there had been a steady—but slow—demand for them in automatic machinery. They were held back, not so much by manufacturing cost as by the lack of sufficient design knowledge about them. Even now, few handbooks or texts on mechanical design include information on such gears—and then too briefly to instill confidence.

Noncircular gears generally cost more than competitive devices such as linkages and cams. But with the development of modern production methods, such as the tape-controlled gear shaper, cost has gone down considerably. Also, in comparison with linkages, noncircular gears are more compact and balanced—and can be more easily balanced. These are important considerations in high-speed machinery. Further, the gears can produce continuous, unidirectional cyclic motion—a point in their favor when

compared with cams. The disadvantage of cams is that they offer only reciprocating motion.

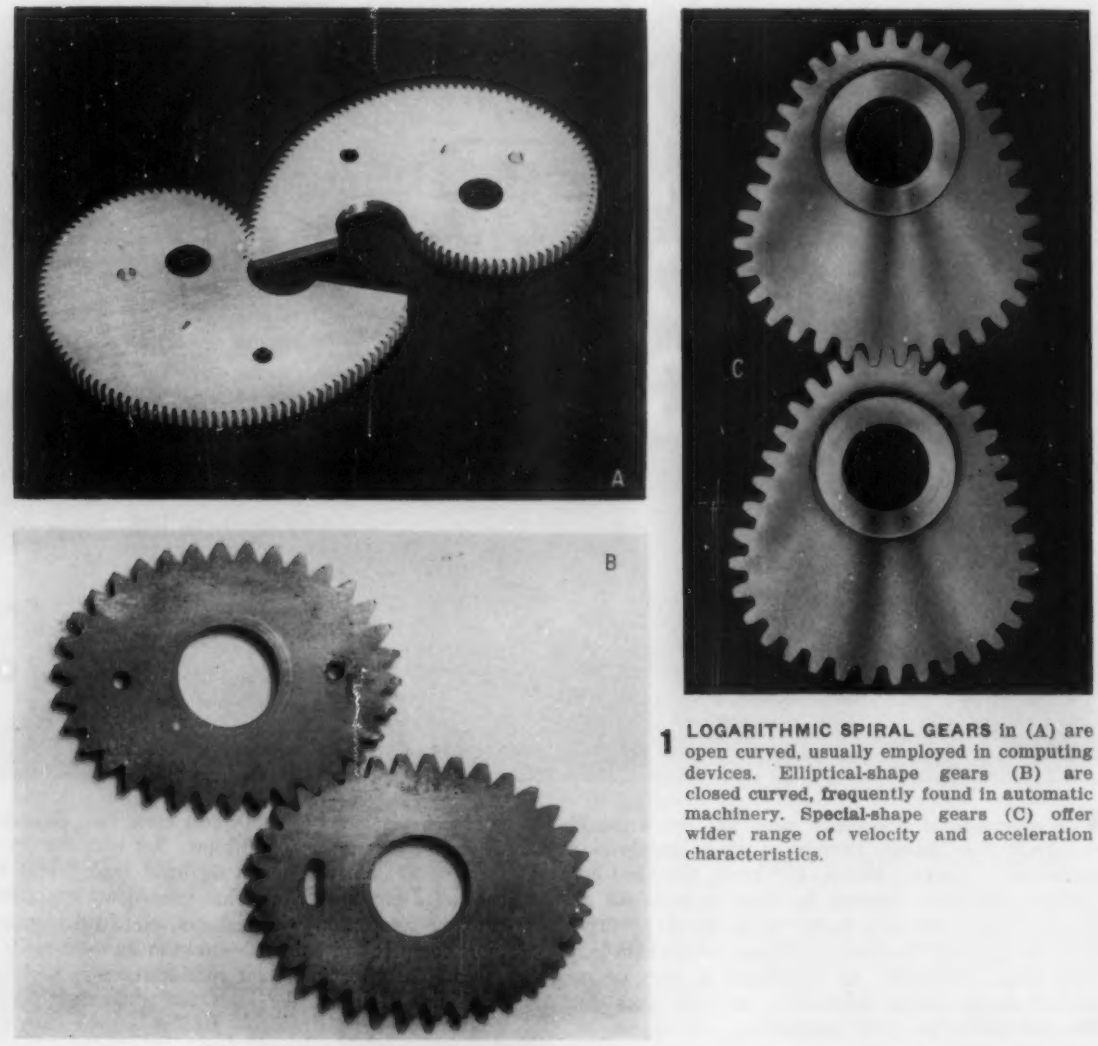
Applications can be classed into two groups:

- Where only an over-all change in angular velocity of the driven member is required: quick-return drives, intermittent mechanisms as in printing presses, planers, shears, winding machines, automatic-feed machines.
- Where precise, nonlinear functions must be generated, as in computing machines for extracting roots of numbers, raising numbers to any power, generating trigonometric and logarithmic functions.

TYPES OF NONCIRCULAR GEARS

It is always possible to design a special-shaped gear to roll and mesh properly with a gear of any shape—sole requirement is that distance between the two axes must be constant. However, the pitch line of the mating gear may turn out to be an open curve, and the gears can be rotated only for a portion of a revolution—as with two logarithmic-spiral gears (illustrated in Fig 1).

True elliptical gears can only be made to mesh properly if they are twins, and if they are rotated about their focal points. However, gears resembling ellipses can be generated from a basic ellipse. These "higher-order" ellipses (see Fig 2) can be meshed in various interesting combinations to rotate about centers *A*, *B*, *C* or *D*. For example, two 2nd-order elliptical gears can be meshed to rotate about their geometric center; however, they will produce two complete speed cycles per revolution. Difference in contour between a basic ellipse and a 2nd-order ellipse is usually very slight. Note also that the 4th-order "ellipses"



1 LOGARITHMIC SPIRAL GEARS in (A) are open curved, usually employed in computing devices. Elliptical-shape gears (B) are closed curved, frequently found in automatic machinery. Special-shape gears (C) offer wider range of velocity and acceleration characteristics.

resemble square gears (this explains why the square gears, sometimes found as ornaments on tie clasps, illustrated in Fig 3, actually work).

A circular gear, mounted eccentrically, can roll properly only with specially derived curves (shown in Fig 4). One of the curves, however, closely resembles an ellipse. For proper mesh, it must have twice as many teeth as the eccentric gear. When the radiis r, and eccentricity, e, are known, the major semi-axis of the elliptical-shape gear becomes $2r + e$, and the minor $2r - e$. Note also that one of the gears in this group must have internal teeth to roll with the eccentric gear. Actually, it is possible to generate internal-tooth shapes to rotate with noncircular gears of any shape (but, again, the curves may be of the open type).

Noncircular gears can also be designed to roll with special-shaped racks (shown in Fig 5). Combinations include: an elliptical gear and a sinusoid-like rack (a 3rd order ellipse is illustrated but any of the elliptical rolling curves can be used in its place—main advantage is that when the ellipse rolls, its axis of rotation moves along a straight line); and a logarithmic spiral and straight rack (the rack, however, must be inclined to its direction of motion by the angle of the spiral).

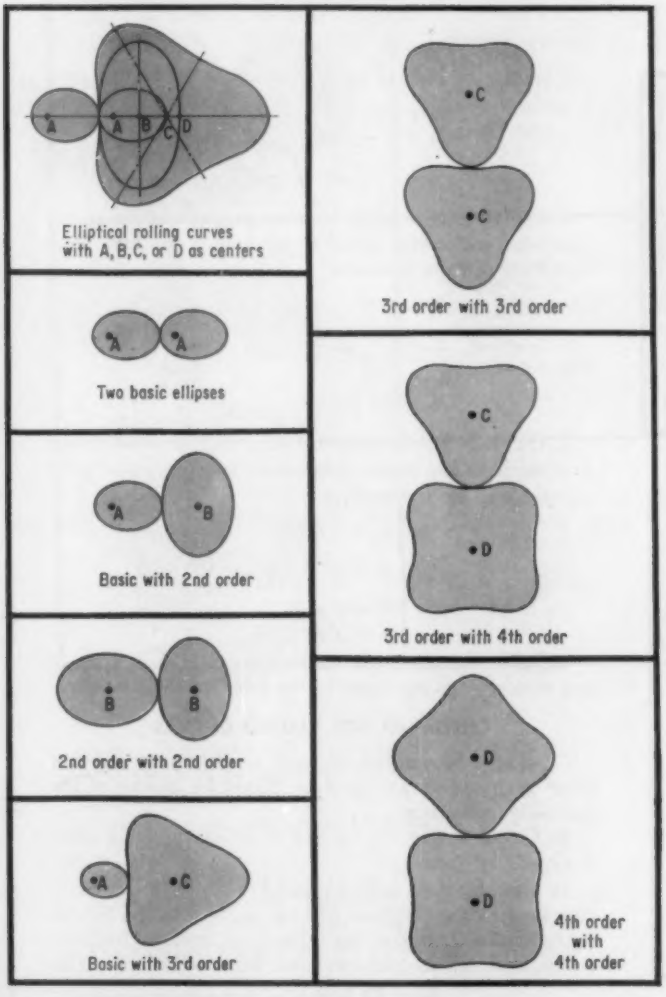
DESIGN EQUATIONS

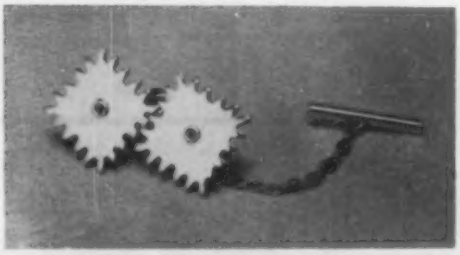
Equations for noncircular gears are shown here in functional form for three common design requirements. They are valid for any noncircular gear pair. Symbols are defined in the box on the next page:

CASE I—Polar equation of one curve and center distance

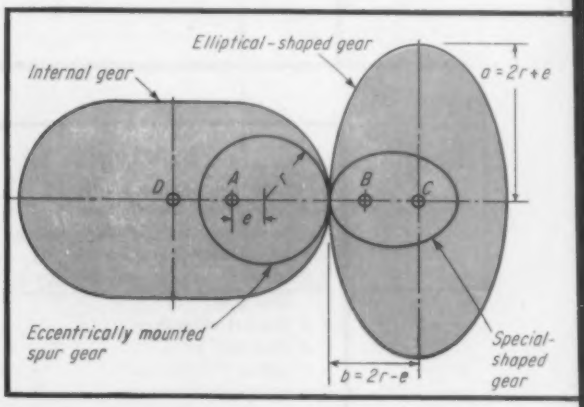
continued, next page

2 Basic and High-order Elliptical Gear Combinations

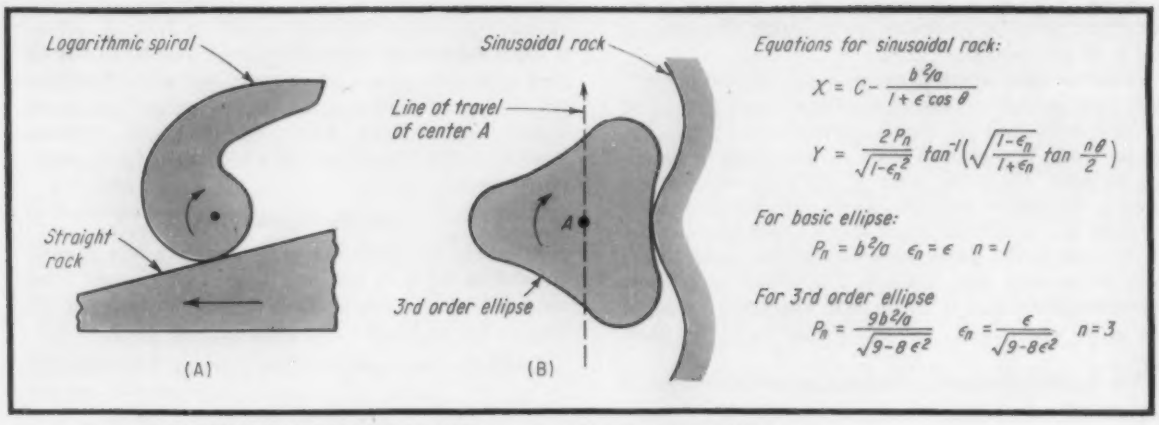




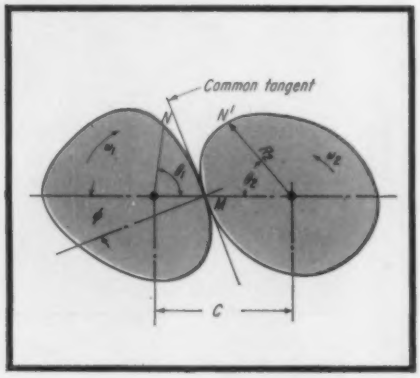
3 SQUARE GEARS ON TIE CLASP seem to defy basic kinematic laws, are actually a takeoff on a pair of 4th order ellipses.



4 ECCENTRIC SPUR GEAR rotating about point A, will mesh properly with any of the three gears shown with centers at points B, C and D.


Logarithmic spiral
Straight rack
(A)
Sinusoidal rack
Line of travel of center A
3rd order ellipse
A
(B)
Equations for sinusoidal rack:
$X = C - \frac{b^2/a}{1+\epsilon\cos\theta}$
$Y = \frac{2P_n}{\sqrt{1-\epsilon_n^2}} \tan^{-1}\left(\sqrt{\frac{1-\epsilon_n}{1+\epsilon_n}}\tan\frac{n\theta}{2}\right)$
For basic ellipse:
$P_n = b^2/a \quad \epsilon_n = \epsilon \quad n = 1$
For 3rd order ellipse
$P_n = \frac{9b^2/a}{\sqrt{9-8\epsilon^2}} \quad \epsilon_n = \frac{\epsilon}{\sqrt{9-8\epsilon^2}} \quad n = 3$

5 **RACK AND GEAR COMBINATIONS** are possible with noncircular gears. Straight rack for logarithmic spiral (A) must move obliquely; center of 3rd order ellipse (B) follows straight line.



Symbols

a = semi-major axis of ellipse
b = semi-minor axis of ellipse
C = center distance (see above sketch)
ϵ = eccentricity of an ellipse = $\sqrt{1-(b/a)^2}$
e = eccentricity of an eccentrically mounted spur gear
N = number of teeth
P = diametral pitch
r_c = radius of curvature
R = active pitch radius
S = length of periphery of pitch circle
X, Y = rectangular coordinates
θ = polar angle to R
ϕ = angle of obliquity
ω = angular velocity
$f(\theta)$, $F(\theta)$, $G(\theta)$ = various functions of θ
$f'(\theta)$, $F'(\theta)$, $G'(\theta)$ = first derivatives of functions of θ

are known; to find the polar equation of the mating gear:

$$R_1 = f(\theta_1)$$
$$R_2 = C - f(\theta_1)$$
$$\theta_2 = -\theta_1 + C\int \frac{d\theta_1}{C - f(\theta_1)}$$

CASE II—Relationship between angular rotation of two members and center distance are known; to find polar equations of both members:

$$\theta_2 = F(\theta_1)$$
$$R_1 = \frac{C\,F'(\theta_1)}{1 + F'(\theta_1)}$$
$$R_2 = C - R_1 = \frac{C}{1 + F'(\theta_1)}$$

CASE III—Relationship between angular velocities of two members and center distance are known; to find polar equations of both members:

$$\omega_2 = \omega_1 G(\theta_1)$$
$$R_1 = \frac{C\,G(\theta_1)}{1 + G(\theta_1)}$$
$$R_2 = C - R_1$$
$$\theta_2 = \int G(\theta_1)\,d\theta_1$$

Velocity equations and characteristics of five types of noncircular gears are listed in the table on the next page.

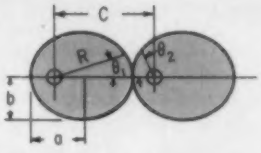
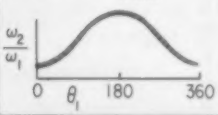
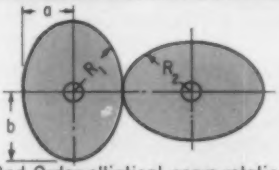
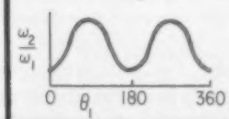
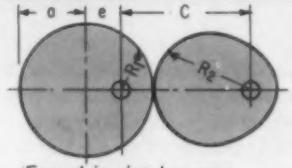
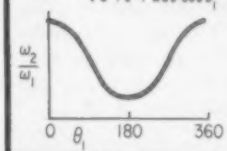
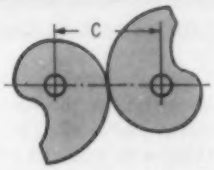
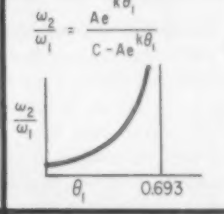
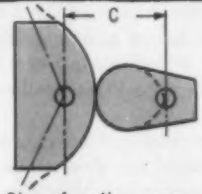
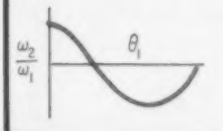
CHECKING FOR CLOSED CURVES

Gears can be quickly analyzed to determine whether their pitch curves are open or closed by means of the following equations:

In Case I, if $R = f(\theta) = f(\theta + 2N\pi)$, the pitch curve is closed.

In Case II, if $\theta_1 = F(\theta_2)$ and $F(\theta_0) = 0$, the curve is closed when the equation $F(\theta_0 + 2\pi/N_1) = 2\pi/N_2$ can be satisfied by substituting integers or rational fractions for N_1 and N_2. If fractions must be used to solve this

Characteristics of Five Noncircular Gear Systems

Type	Comments	Basic equations	Velocity equations ω_1 = constant
 Two ellipses rotating about foci	Gears are identical. Comparatively easy to manufacture. Used for quick-return mechanisms, printing presses, automatic machinery	$R = \frac{b^2}{a[1+\epsilon\cos\theta]}$ ϵ = eccentricity $= \sqrt{1-\left(\frac{b}{a}\right)^2}$ $a = \frac{1}{2}$ major axis $b = \frac{1}{2}$ minor axis	$\omega_2 = \omega_1\left[\frac{r^2+1+(r^2-1)\cos\theta_2}{2r}\right]$ where $r = \frac{R\,max}{R\,min}$ 
 2nd Order elliptical gears rotating about their geometric centers	Gears are identical. Geometric properties well known. Better balanced than true elliptical gears. Used where two complete speed cycles are required for one revolution	$R = \frac{2ab}{(a+b)-(a-b)\cos 2\theta}$ $C = a+b$ a = maximum radius b = minimum radius	$\omega_2 = \omega_1\left[\frac{r+1+(r^2-1)\cos 2\theta_2}{2r}\right]$ where $r = \frac{a}{b}$ 
 Eccentric circular gear rotating with its conjugate	Standard spur gear can be employed as the eccentric. Mating gear has special shape	$R_1 = \sqrt{a^2+e^2+2ae\cos\theta_1}$ $\theta_2 = \theta_1 + C\int\frac{d\theta_1}{C-R_1}$ $C = R_1 + R_2$	$\frac{\omega_2}{\omega_1} = \frac{\sqrt{a^2+e^2+2ae\cos\theta_1}}{C-\sqrt{a^2+e^2+2ae\cos\theta_1}}$ 
 Logarithmic spiral gears	Gears can be identical although can be used in conbinations to give variety of functions. Must be open gears	$R_1 = Ae^{k\theta_1}$ $R_2 = C-R_1$ $= Ae^{k\theta_2}$ $\theta_2 = \frac{1}{k}\log(C-Ae)^{k\theta_1}$ e = natural log base	$\frac{\omega_2}{\omega_1} = \frac{Ae^{k\theta_1}}{C-Ae^{k\theta_1}}$ 
 Sine-function gears	For producing angular displacement proportional to sine of input angle. Must be open gears	$\theta_2 = \sin^{-1}(k\theta_1)$ $R_2 = \frac{C}{1+k\cos\theta_1}$ $R_1 = C-R_2$ $= \frac{Ck\cos\theta_1}{1+k\cos\theta_1}$	$\frac{\omega_2}{\omega_1} = k\cos\theta_1$ 

equation, the curve will have double points (intersect itself), which is, of course, an undesirable condition.

In Case III, if $\theta_2 = \int G(\theta_1)\,d\theta_1$, let $G(\theta_1)\,d\theta_1 = F(\theta_1)$, and use the same method as for Case II, with the subscripts reversed.

With some gear sets, the mating gear will be a closed curve only if the correct center distance is employed. This distance can be found from the equation:

$$4\pi = \int_0^{2\pi} \frac{d\theta_1}{C - f(\theta_1)}$$

ANGLE OF OBLIQUITY

It is also desirable to avoid too great an angle between the common normal to the mating pitch curves at the point of tangency and the line of centers (called the angle

continued, next page

of obliquity, ϕ). This angle is equal to

$$\phi = \tan^{-1}\left(\frac{f'(\theta)}{f(\theta)}\right)$$

where $f'(\theta)$ is the first derivative of $f(\theta)$. This angle should not exceed 45°, to prevent the teeth from pulling out of engagement.

It is often necessary to know if the pitch curve contains a reverse portion. This condition exists if, in the equation for the angle of obliquity ϕ_1, there is more than one value of θ for each value of ϕ during any π-range of θ (or any 180° range of θ).

DETERMINING NUMBER OF TEETH

As with circular gears, it is desirable to know if the teeth of noncircular gears are in danger of being undercut. According to AGMA standards, to avoid danger of undercutting when the outside diameter of a gear is $(N + 2)/P$, the minimum number of teeth should be 18.

For a smaller number of teeth, the outside diameter can be made oversize in accordance with AGMA standards. This principle can be applied to noncircular gears by determining the instantaneous radius of curvature of the pitch curve and multiplying it by twice the diametral pitch. If the answer is less than 18, there is danger of undercut. However, this does not usually become serious until the number is 12 or less.

The radius of curvature, r_c, can be determined from the following equation where $R = f(\theta)$ is the polar equation of the pitch curve, and R' and R'' are first and second derivatives of R:

$$r_c = \frac{[R^2 + (R')^2]^{3/2}}{R^2 - R(R'') + 2(R')^2}$$

All of the above properties (open or closed gears, angle of obliquity, reverse curvature, radius of curvature) can be determined from a carefully made, large-scale layout of the pitch curve. When the formula is unknown and the pitch curves have been determined empirically, layout is the only method available. However, even when the polar equation is known, the equation for angle of obliquity and radius of curvature may be hard to solve and a layout will determine these values to sufficient accuracy.

Number of teeth in a noncircular gear is determined as follows. Find the length of the periphery of the pitch curve. If it is a closed gear, employ the equation:

$$S = \int_{\theta}^{\theta+2\pi} [(dR)^2 + (Rd\theta)^2]^{1/2}$$

If this is too hard to solve, the length can usually be approximated from a careful layout. For elliptical gears, the length can be approximated from the equation:

$$S = \pi\sqrt{2(a^2 + b^2) - \frac{(a-b)^2}{2.2}}$$

For open gears, the teeth number is usually not very important because the gears do not make a complete revolution. For closed gears, the number equals SP/π and should, of course, be integral. Also, if the mating gears are identical (elliptical, for example), the teeth number should be odd to insure proper meshing.

The diametral pitch in the formula for number of teeth can be varied slightly to provide the proper number. This, in effect, will make the gears slightly oversize or undersize, depending on whether the pitch is increased or decreased. If this change is under 10%, the flexibility of the involute system will take care of it.

THE MANUFACTURING TECHNIQUES

Simplest method—but also slowest and most expensive—of making noncircular gears involves the division of the gear into several segments, each of which can be considered as approximating an arc of a circle. Each segment is then cut separately on a gear shaper, so set up that the work rotates about the instantaneous center of the segment. Rotation is geared for that segment. This involves danger of considerable error at the junction of two segments.

Perhaps the most accurate way of cutting noncircular gears is the tape-controlled gear shaper. The center distance between cutter and work, and the angular velocity of the work spindle, is varied in accordance with the instructions contained on a previously prepared tape, which can be paper, plastic, film or magnetic. The tape delivers its instructions to the machine through a special control unit.

Such a unit, coupled to a Fellows gear shaper, has been developed and used by Frederick Cunningham, Stamford, Conn. He has made the gears illustrated on page 59. Norden Laboratory Division of Norden-Ketay, and a few others are also using this technique. The method is especially suitable for making masters for the production gears.

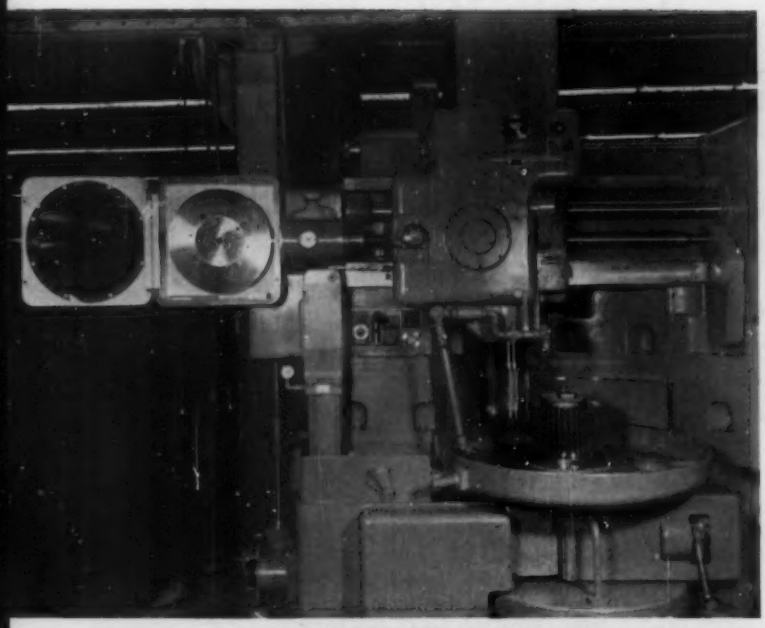
Another way is to mount a special cam on a gear shaper, as illustrated in Fig. 6, to control the center distance of cutter and work spindles. Cutter is held in an eccentric adapter or bushing to vary the linear velocity.

The gear shaper can also act as a copying machine by having a master gear and pinion regulate the velocity ratio and center distance of the cutter and work. This method allows using a standard machine with a special work-holding fixture. The master pinion is a duplicate of the cutter. The master noncircular gear can be generated on the same fixture, using a cam and follower in place of the noncircular gear and pinion. To insure correct rolling action during the cutting, steel tapes are wound around the cam and follower, and the diameter of each is made small enough to allow for thickness of the tape.

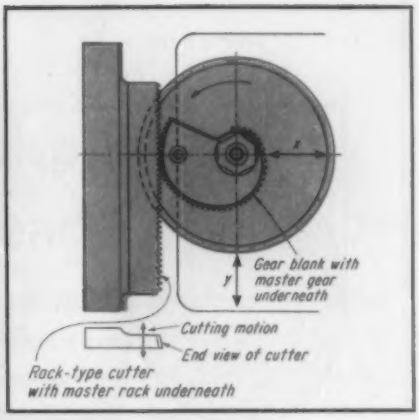
This method has proved successful, although master gear and pinion are usually preferred for production. It also lends itself to using a rack-shaped cutter, (see Fig. 7) with a rack or bar in place of the master pinion or follower. The fixtures are set up on a Fellows 7-Type Gear Shaper. Three motions are imparted to the work.

COMING SOON

More details on designing elliptical gears, including two sample problems, will be given in an article to appear in a forthcoming issue.



6 CAM-CONTROLLED FELLOWS GEAR SHAPER varies the center distance between work and reciprocating cutter. Cutter is held in eccentric adapter.



7 RACK-TYPE CUTTER is operated by master gear and rack directly underneath the work and cutter. As the slide is moved in y direction, the master rack rotates the work-holding outfit through the master gear, and at the same time moves the work in x direction. Thus, three motions are imparted to the work while the rack-type cutter is reciprocating in a direction perpendicular to both x and y to cut the teeth.

Sample Calculations

PROBLEM I—Polar coordinate of one curve is given as: $R_1 = 2 + \cos \theta_1$.

Find the equation of the mating gear and correct center distance.

From the equations for Case I:

$$R_2 = C - (2 + \cos \theta_1)$$

Since

$$dR_1 = -\sin \theta_1$$

Then

$$\theta_2 = -\theta_1 + C \int \frac{d\theta_1}{C - (2 + \cos \theta_1)}$$

$$\theta_2 = -\theta_1 + \frac{C}{\sqrt{C^2 - 4C + 3}} \tan^{-1} \left[\frac{\sqrt{C^2 - 4C + 3} \sin \theta_1}{(C - 2) \cos \theta_1 - 1} \right]$$

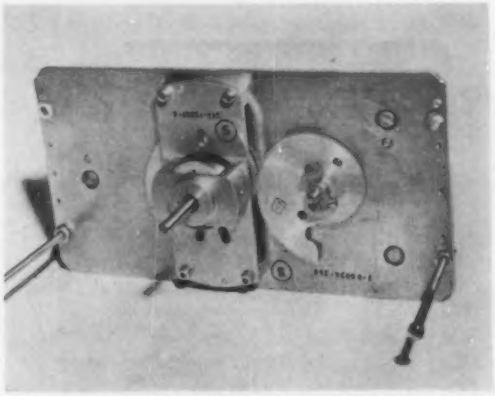
The center distance at which the mating gear will be a closed curve is

$$4\pi = \int_0^{2\pi} \frac{d\theta_1}{C - (2 + \cos \theta_1)}$$

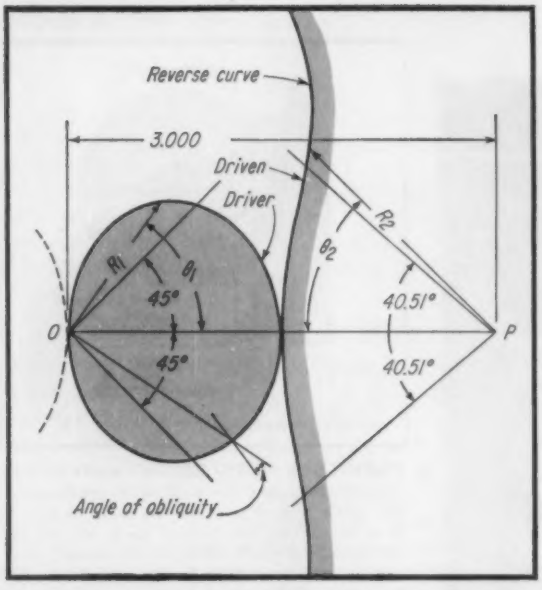
$$4\pi = \frac{2\pi C}{\sqrt{(C - 2)^2 - 1}}$$

$$C = (2/3)(4 + \sqrt{7})$$

This value can be substituted into the equations above



VARIABLE-FREQUENCY OSCILLATOR designed by Arma Div of American Bosch Arma for operational ground equipment serving missiles and space vehicles. Specifically, the noncircular gears convert linear rotation of an input shaft, θ_1, to the nonlinear function: $\theta_2 = (636.43\theta_1)/(\theta_1 + 306.43)$.



CONVERSION OF SINE FUNCTION to a linear function (sin $\theta_1 = \theta_2$) by means of special gears rotating about points O and P. Details pertain to sample problem II.

for R_2 and θ_2. These two equations then define the pitch curve for the mating gear.

Angle of obliquity is

$$\tan \phi = \frac{\sin \theta_1}{2 + \cos \theta_1}$$

This value is never over 45°, and indicates no reversal of the pitch curve because ϕ is single-valued during any multiple of π-range (or 180° range) of θ_1.

Length of the periphery is

$$S = \int_0^{2\pi} \sqrt{\sin^2 \theta_1 + (2 + \cos \theta_1)^2}\, d\theta$$

By trigonometric identities, this equation can be converted to

$$S = 6 \int^{\pi/2} \sqrt{1 - \frac{8}{9} \sin^2 \left(\frac{\theta_1}{2}\right)}\, d\left(\frac{\theta_1}{2}\right)$$

which is in the elliptical-integral form of

$$S = 6 \int \sqrt{1 - k^2 \sin^2 x}\, dx$$

Looking up the value of this integral for $k = \sqrt{8/9}$ in a table such as *Handbook of Mathematical Tables and Formulas*, by Burington (p 279) gives

$$S = 6.68$$

Then, assuming the circular pitch, P, to be 16:

$$N = SP/\pi = 34.04$$

Therefore $N = 34$

PROBLEM II—It is desired to linearize the function sin θ. Thus: $\sin \theta_1 = \theta_2$

where θ_2 is in radians. Final shape of the gears will be similar to those drawn above.

Given center distance = 3 in.; driver oscillates between ±45°. From the equations for Case II:

$$\theta_2 = F(\theta_1) = \sin \theta_1$$

$$R_1 = \frac{C F'(\theta_1)}{1 + F'(\theta_1)} = \frac{3 \cos \theta_1}{1 + \cos \theta_1} = \frac{3}{1 + \sec \theta_1}$$

$$R_2 = \frac{C}{1 + F'(\theta_1)} = \frac{3}{1 + \cos \theta_1} = \frac{3}{1 + \sqrt{1 - \theta_2^2}}$$

Although R_1 is a closed gear—because $f(\theta_1) = f(\theta_1 + 2N\pi)$—$R_2$ is open and is discontinuous when $\theta_2 = 1$. The gears will, however, operate satisfactorily within the range desired. Inspection indicates that the formulas for length of curve, radius of curvature, and angle of obliquity are not subject to ready solution, and the curves are therefore laid out; see illustration at left. Length of the driver curve between ±45° is approximately 2.29 in. Using 48 pitch (0.0655 circular pitch) there will be 35 teeth in this portion of the curve. Approximate min radius of curvature from the layout is 0.8 in., giving 76 teeth, which will present no undercutting problem.

The layout shows no reverse curve in the usable portions of the two curves, and the angle of obliquity is always less than 45°. The driver has double points (crosses itself) at $\theta_1 = 90°$. Driven is discontinuous at $\theta_2 = 57.3$.

PROBLEM III—Desired velocity relationship between two shafts is $\omega_1 = \omega_2 B \cos \theta_1$ where B is a constant. Required angular displacement of θ_2 is from +45° to −45°. From equations for Case III:

$$G(\theta_1) = B \cos \theta_1$$

$$R_1 = \frac{C B \cos \theta_1}{1 + B \cos \theta_1}$$

$$\theta_2 = \int B \cos \theta_1 d\theta_1 = B \sin \theta_1$$

$$R_2 = \frac{C}{1 + B \cos \theta_1} = \frac{C}{1 + \sqrt{B^2 - \theta_2^2}}$$

Equation for R_1 is a closed curve if $B < 1$ (although the equation may cross itself); but R_2 is discontinuous when $\theta_2 = B$. However the curves are valid for the portion specified (±45°).

Angle of obliquity is:

$$\tan \phi = (B - 1)\left[\frac{\sin \theta_2 + B \sin \theta_2 \cos \theta_2}{\cos \theta_2 (1 + B \cos \theta_2)}\right]$$

Here, ϕ is less than 45° and single valued for the range given, indicating no reversals. Also, since $\phi = 0$ when $\theta_2 = 0$, there can be no great change of curvature during the interval 0 to 45°. A layout will verify this, and for the purposes of this combination, a comparatively fine pitch (32 or 48) can be used.

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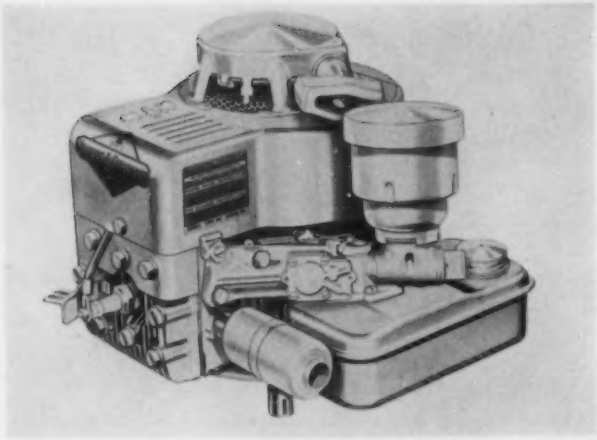
EDITOR'S NOTE: For information on recent developments in gearing see:

The Harmonic Drive—Innovation in High-ratio Gearing, Feb 8 '60, p 47. A flexible ring gear rolls at a slow pace inside a fixed ring gear.

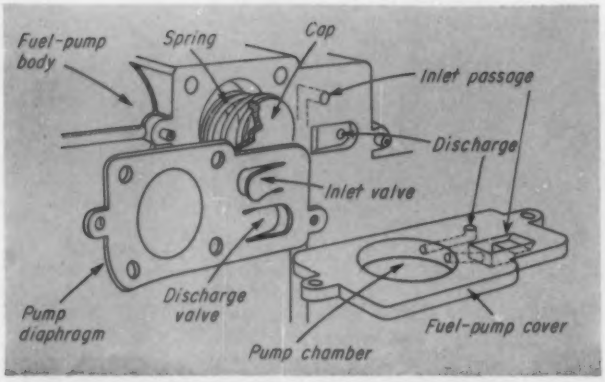
Novel Concept Gives Record Gear Ratios, June 22 '59, p 67. Helical gears are paired with spur gears.

Cam Control Gets More Out of a Planetary Gear, Jan 4 '60, p 38. Grooved cam in place of ring gear.

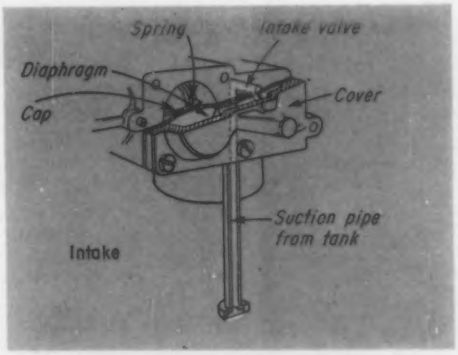


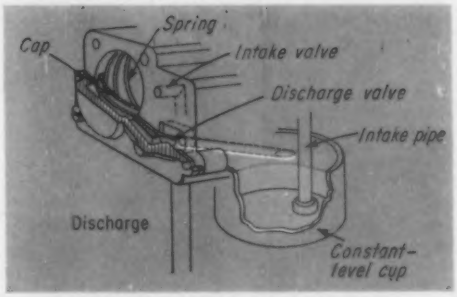
Pulse Pump Steadies Fuel Flow

This carburetor avoids pressure variations inherent in a gravity-feed tank. The key: a small and separate reservoir that's kept full by a diaphragm pump drawing fuel up from the main tank.



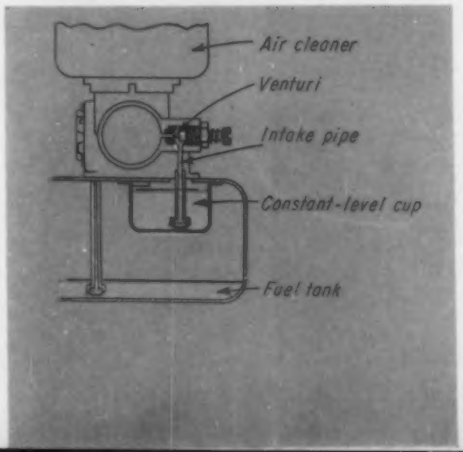
ONLY ONE MOVING PART characterizes this pump. It's simply a diaphragm—neoprene-impregnated nylon into which two flap valves have been cut. Its pulsing action obviates need for check-valves at bottom of fuel pipes. The multipurpose diaphragm also acts as seal between body and cover of this fuel pump.





INTAKE-STROKE VACUUM in the carburetor elbow pulls cap and diaphragm inward, compressing the spring. Reduced pressure created on "cover side" of the diaphragm draws gasoline up the suction pipe from the tank, through the intake valve and into the pump. When vacuum drops at end of intake stroke, the spring-loaded cap is pushed back. Resulting pressure closes intake valve and opens discharge valve. Fuel now drops down into fuel cup that supplies the carburetor. The cycle repeats for every other stroke, keeping fuel cup full—excess gasoline flows over rim of cup back to the tank.

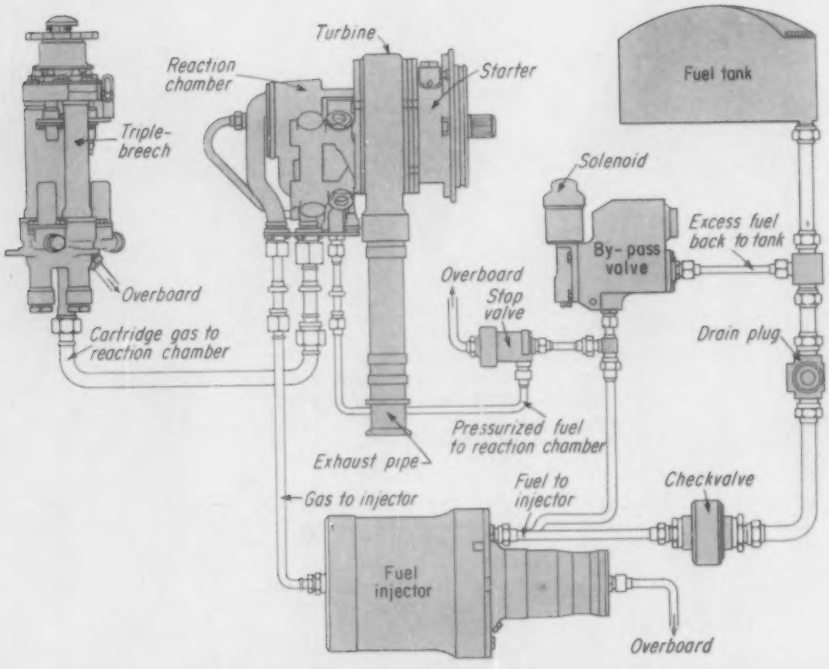
The venturi in the carburetor is connected to the intake pipe that draws up gasoline from the fuel cup. Constant level maintained at the venturi intake provides a constant fuel-air ratio regardless of of fuel level in main tank.



PS . . . Fuel pump and constant-level fuel chamber replace the conventional gravity-feed tank, float and float chamber of a carburetor. Since fuel chamber is directly below the carburetor's venturi, less "lift" is required to raise fuel. Larger venturi permits increased flow of mixture to cylinder, raises efficiency. "Pulsa-jet" carburetor developed and produced for single-cylinder engines by Briggs & Stratton Corp, Milwaukee.

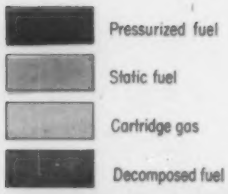
Jet Engine Starts with a Bang

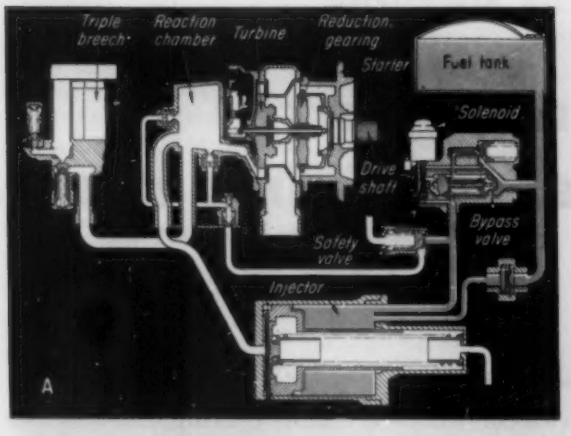
Cartridge ignition here triggers mono-fuel starting system of aircraft turbine. The self-contained, lightweight unit produces over 3 hp per lb to eliminate need for ground starting systems. Under normal conditions the engine starts in 5 to 6 seconds.

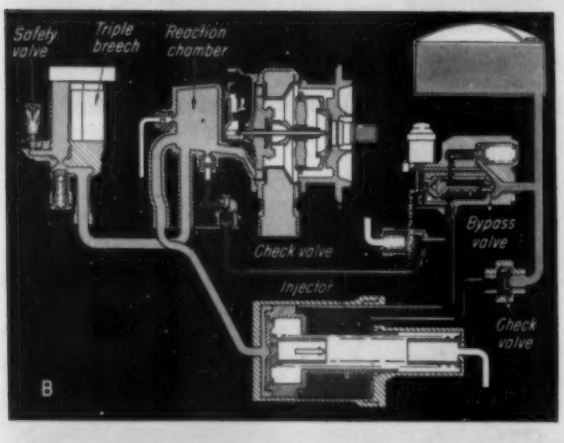


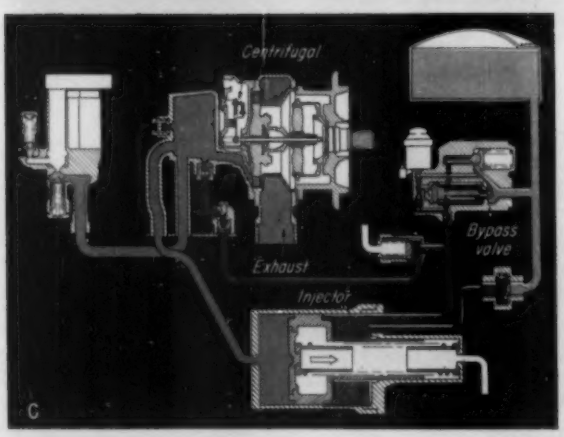
ISOPROPYL NITRATE FUEL needs no air for combustion. It decomposes when the critical temperature and pressure conditions are reached. Firing is initiated by a cordite cartridge that also actuates the fuel-injection piston. Initial supply of fuel from the injector decomposes into gas that maintains pumping action of the injector, also drives the starter—turbine-geared to the main engine and running at a maximum of 45,000 rpm. When the main engine reaches 10,000 rpm, fuel to the reaction chamber is cut off and remaining pressurized fuel bypasses to storage tank.

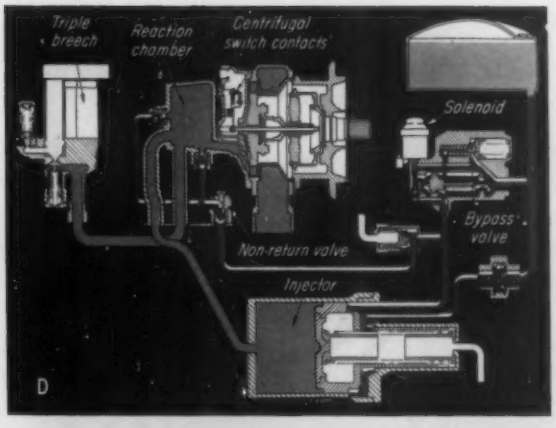
PS . . . New starter weighs 111 lb excluding pipework, fuel tanks and wiring; requires 2 amps at 16-24 v; uses 4.6 pints of fuel per cycle; produces 380 hp at 10,000-rpm turbine speed. Safety features: fail-safe bucket-wheel rotors, with drilled blades that strip off under overspeed conditions; gas and fuel pressure-relief valves; starter and breech checkvalves; a time switch that monitors max "on" time, prevents restart within 30 sec. Bristol Aircraft type 192 helicopter is powered by Napier Gazelle NGa.2 free-turbine engines using mono-fuel turbo-starter produced by Associated Electrical Industries, Rugby, England.

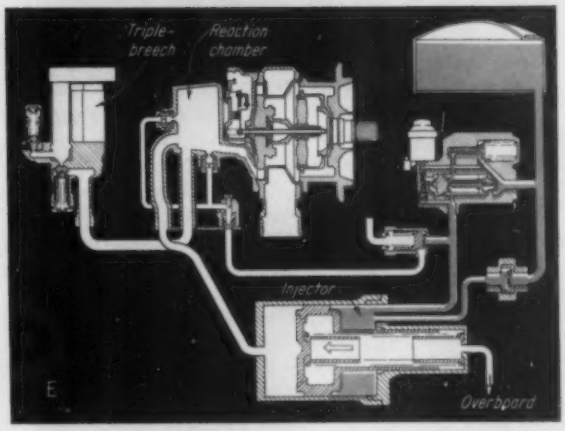












WITH THE SYSTEM AT REST (A), fuel is gravity-fed to injector and bypass valve. When the operating button is depressed, one cordite cartridge in the triple breech is selected and fired. This pressurizes the reaction chamber to 200 psi (B) and also the differential piston of the fuel injector, thereby pressurizing fuel on the other side. This fuel is passed to the reaction chamber where it decomposes, maintains the gas supply to the injector piston, and drives the starter turbine. Non-return valves ensure the correct routing of fuel and gas. Self-sustaining gas-generating conditions are reached in ½ sec.

Gas pressure in the reaction chamber rises rapidly to its steady state of 1100-1300 psi (C) and steady running pressure is reached when the injector pressure gain is balanced by losses in the pipes, spray nozzles, valves and restrictor.

At disengagement speed, a centrifugal switch in the turbo-starter (D) breaks the electrical circuit to the bypass solenoid valve. This releases fuel pressure and returns unused fuel to the fuel tank.

As gas pressure falls (E), the injector piston returns and draws a further fuel supply through the sensitive non-return valve. Normal engine starts are achieved in 5-6 sec; however, if the main engine does not start, a time switch shuts the starter system off. Time-delay switch prevents recycling of system for 30 sec.

After peen plating, spring-steel hose clamps retain ductility.

no heat, no electricity . . .

PLATING PARTS BY PEENING THEM

Just let a tumbler barrel do the work. It's a patented low-cost way to give a corrosion-resistance coating with zinc and other metal powders. As a service to its readers, PRODUCT ENGINEERING searched original source material for details about this new and still unpublicized process.

HEBERT L KEE, *assistant editor*

In the half dozen years since the first patent was granted for peen plating, the method has grown from developmental to commercial stature. It now provides a low-cost way to coat one metal with another—the feature here is that coating is done with metal powder. No heat or electricity is required, as in electroplating or hot-dipping. Peen plating, like ordinary tumbling, is a finishing step done on a rotating barrel. Pellets and grit provide the peening medium—tiny hammers that pound the powder onto the parts being plated. Key to success of this unique cold-welding method is an inhibited cleaner that serves as a chemical "promoter."

Other assets that peen plating offers over competing processes: freedom from hydrogen embrittlement, plating of unorthodox alloys, easy plating of metal-powder parts, and of such hardened parts as carburized and nitrided parts. Also, under special conditions, peen plating will deposit onto glass, ceramics, refractory nitrides and carbides.

FOR MORE ABOUT THIS PROCESS

Though peen plating itself is relatively simple, information about the process has not been readily available. However, here are some sources to which the reader can go directly:

Brief mention of the process was contained in our Design Show Report (June 8 '59, p 45). At that time, however, the Minnesota Mining & Mfg Co—exclusive licensers for US and Canada—was not ready to give details because the process was still under wraps in 3M's developmental laboratory.

The original US patent, No. 2,640,-002, was issued to E. T. Clayton in 1953, and assigned to Peen Plate Inc, a licensing subsidiary set up by the Tainton Co, 3100 Elm Ave, Baltimore. Subsequently, England issued these three patents to the Tainton Co: in 1955, Nos. 740,075 and 740,104; in 1957, No. 870,933.

Meanwhile, the process was also described in detail by G. H. Jenner, at that time manager of the Peen Plate Dept of the Schori Div of F W Berk Co, London—the principal European licensee. His paper, "Peen Plating," was published in *Transactions of the Institute of Metal Finishing* (1957, 34, pp 253-269). This paper, in turn, contained comparative corrosion data on plated bolts from a 1956 report by the US National Bureau of Standards (Report No 4845).

It is common enough now, in a two-barrel operation, to coat four tons of hardware parts daily. These parts can be almost any metal except stainless steel, titanium and magnesium. The powder applied by mechanical impact is of a "soft" metal. Zinc, so far, is the most popular coating material. Brass, cadmium, tin and lead are others. And it is expected that aluminum will eventually be still another.

PROPERTIES OF THE COATINGS

Besides its comparative cheapness, the method has technical advantages. It gives coatings free from hydrogen embrittlement and without a brittle alloy layer. Major advantage is cheapness of the procedure—because of the low labor cost and efficient use of material.

The percentage of metal deposited approaches 100% for certain metals. For zinc this means substantial material savings over hot dipping where losses from oxidation alone are from 20 to 60%.

Economy also results from the fact that barrel finishing needs only a small amount of unskilled labor. Total labor varies from 5 to 20 min. per batch and no chemical analysis of the powder or baths is required.

Coating thicknesses can be had from 0.0001 to 0.005 in. The process for zinc coatings takes from 20 minutes to 1½ hours, depending on shape of the parts. But the nature of the process limits it to small parts with surfaces that can be reached by the impacting media—deep, narrow crevices cannot be plated successfully.

The method is essentially one of building up coatings by successively welding small powder particles onto the parts. This gives a laminated structure of built-up flakes which follows the contours of the part and has a uniform appearance. Total variation in thickness is about 5 to 10%. Adhesion is good enough to remain on the head of a driven nail or when a nail is given a 90° sharp bend.

Peen-plated zinc on steel is superior to electrodeposited zinc or cadmium in withstanding salt spray. Corrosion results reported by the US National Bureau of Standards are given in the table on this page. The data, obtained in outdoor-exposure tests at Norfolk, Va, show that 0.0002 in. of peen-plated zinc is more resistant to salt corrosion than the equivalent thickness of electroplated zinc or cadmium, and almost as corrosion resistant as 0.0005 in. of electroplated cadmium.

ZINC AS COATING

The most common material plated by this process is zinc. Usually the parts, after degreasing and acid etching, are given an immersion copper plating about 0.000,02 in. thick. The still-wet parts are then put into a barrel for the main coating.

A typical charge for a 30-in.-dia x 30-in.-long barrel consists of 1200 lb of ⅛-in. pellets, 200 lb of 18-mesh steel grit, 400 lb of parts, 8 lb of zinc dust, promoter and water. Rotating the barrel at 24 rpm for 90 minutes gives a zinc coating of about 0.0003 in. After tumbling, the impacting media is screened out and both the liquid and excess powder are discarded. Commercial practices coat over 95% of the zinc powder onto the part.

In general, thickness for zinc coatings ranges from 0.0001 to 0.002 in. In special instances, coatings up to 0.005 in. can be obtained. Coating thickness is controlled by the amount of powder. To double the thickness, double the amount of powder. The processing time itself depends only on shape and size of the part. That is, for a given part, the time needed to build up a coating is the same, whether for a thick or thin coating. The coated parts then may be given other treatments like chromate to increase the corrosion resistance.

BRASS AND OTHER COATINGS

Peen-plating brass differs from the zinc method in several respects. Brass powder is reused, because the plating

Comparison of Marine Corrosion on Plated Bolts

(From Report 4845, 1956, by F. M. Reinhart, US National Bureau of Standards)

	PEEN-PLATED	ELECTROPLATED		
Exposure, months	Zinc, 0.0002-in.	Cadmium, 0.0002 in.	Zinc, 0.0002 in.	Cadmium, 0.0005 in.
6	Dull—white corrosion products	Gray corrosion products	Dull—white corrosion products	Dull
12	Dark gray	15% rust on bolt head	25% rust on threads 100% on nuts	Dull gray
27	Trace of rust on threads, remainder gray	100% rust	100% rust	Dark gray

efficiency of fresh brass powder is low. Hot water is also necessary for high efficiencies. Copper immersion plating is not needed, but for metals that are difficult to coat, a lead strike is first impacted on by adding up to 10% lead powder in the metal charge. In general, brass plating takes longer—up to 2 hours, and builds up thinner deposits—about 0.0002 in.

Other metals, such as cadmium, lead and tin—and their alloys—can be plated easily but thick coatings of tin tend to be lumpy and less uniform. Mechanically plated copper has a satin finish similar to other peen-plated parts and cannot be buffed to give a satisfactory underlay for bright chromium plate.

In alloy plating, the process contributes the advantages of powder metallurgy. Any combination of alloys platable by the process can be deposited in any ratio for specific properties: for example, lead-tin for easy soldering and cadmium-tin for salt-spray resistance.

THESE LIMITATIONS

Shape and size of the part must permit the impacting particles to impinge on the surface—the reason why crevices cannot be plated. Deep crevices may also cause the particles to lodge and become difficult to remove.

Costs go up as the parts get larger—because more tumbling media or impacting material must be added to prevent large parts from hitting each other. This means that in a given barrel, weight of large parts that can be treated is less than weight of smaller parts would be.

Coating materials are limited to the soft metals because the powder must be soft enough to be squashed by the tumbling forces. Base metal is limited too. It must be easily cleanable, yet not too reactive. This eliminates such hard-to-clean metals as titanium and stainless steel, and the active metals like magnesium.

THE TUMBLING PROCESS

Cleaning and preparation of the parts consists of three steps: degreasing, etching and precoating. For degreasing, vapor processes are preferred because they do not leave residues that may interfere with coating. Etching to roughen the surface may be necessary for base metals that do not have good adhesion, and for heavy coatings. Acid etching is generally used, but introduces hydrogen embrittlement. This can easily be avoided by substituting grit blasting. The precoat—a thin immersion copper plate—protects the cleaned surface until the zinc can be plated. An alternate to precoating is a strike coating put on as part of the tumbling step. Up to 10% of a soft metal powder—tin, for example—is added to the metal powder in the barrel. The softer tin precoats the base metal and aids later adherence of the coating.

Tumbling with the various ingredients then coats the parts. Essential ingredients include the metal powder, water, chemicals and the tumbling or impacting materials. The metal-powder feed should be free from oxide and in fine small spheres. Amount of powder can be calculated from the area to be coated and the plating efficiency of the metal—percentage of the powder deposited as coating. Where the part has a complicated shape, and surface area is difficult to determine, the amount of metal powder can be determined empirically.

The tumbling media may be one or a combination of several materials: steel grit or shot, glass beads of various sizes, or the alumina tumbling media used in other barrel-finishing operations. Usually an assortment of sizes is used—large particles for better compacting and welding; small particles for uniform appearance and coating of small fillets at corners. The amount of beads or shot varies with the size of the barrel and the amount of work loaded. Before using, the impacting material must itself be plated with the coating metal. Once coated, the impacting materials retain a thin layer that will not increase in thickness. This means that the impacting material cannot be used interchangeably for coating different metals.

Water is essential to peen plating—the amount needed increases with the amount of load and is usually the quantity sufficient to submerge the charge to a depth of 2 in. No special softening treatment is normally required.

Chemical additives called promoters aid the cold welding of the impacted powders. Without them, the process would not work. These promoters consist of two parts: mild pickling agents that clean oxides from base metal, and inhibitors that prevent attack of metal itself. The peen-plating patents cover many materials that can be used in promoters. Among the pickling agents are carboxylic acids, ammonia, and complex nitrogen-containing compounds. Patented inhibitors include natural hydrophilic colloids such as starches, cellulose derivatives, nitrogen derivatives and amines.

EDITOR'S NOTE: Other articles on coating processes for protection against corrosion and high-temperature oxidation:

Which Coating at High Temperature, Jan 20 '58, p 61. Guide to best coating type for corrosion resistance, erosion protection, and compatibility with base metal.

Vacuum Coatings Go Industrial, Dec 23 '57, p 67. Vacuum-deposited coatings, once limited to decorative uses, also offer corrosion resistance at low cost.

Hot-dipped Aluminum Coatings, Oct 28 '57, p 57. Aluminum hot-dipping allows substitution of less costly materials, cuts fabricating costs, and reduces maintenance.

Plated Finishes—the Choice Widens, Oct 28 '57, p 81. Electroplated alloys give coating properties that single-metal deposits cannot match. Chart guides selection of both types.

Chromizing for Resistance to Corrosion and Wear, Nov '56, p 180. How diffusion of chromium into steel increases its oxidation resistance and wear properties.

Plasma-arc Plating, Dec 8 '58, p 104. Working temperatures of over 20,000 F permit the plasma-arc torch to melt and deposit any known metal or ceramic. Gives properties of some coatings and design parameters for the process.

Porcelain Coatings on Steel, Feb 17 '58, p 75. Basic facts to simplify design for new enamels, which permit one-coat porcelain on steel.

Which Finish for a Zinc Die Casting? Mar 3 '58, p 59. Chart to guide choice of finish from mechanical, chemical, plating and painting methods.

New Look in Porcelain Enamel, Nov 24 '58, p 53. When choosing an enameling process for pattern and color, it is important to know the engineering properties required.

SPECIFICATION for the National Supply Co exhibit for the International Petroleum Exposition at Tulsa: "Hang a 30-ft globe in air on top of a 45-ft building in tornado country, rotate it at 2 rpm, show as little support as possible." The job was done by . . .

DESIGNING A REINFORCED-PLASTICS SPHERE

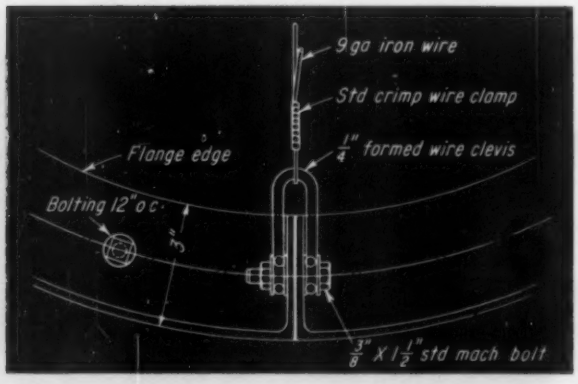
JOHN A WILLS, *plastics consultant, Pasadena, Calif.*

1 FIBERGLASS-REINFORCED, POLYESTER-RESIN LAMINATES were selected for skin materials because of their high strength-weight ratio, decorative character and low fabrication cost. The globe was designed in 24 equal half-orange-peel segments for ease of construction, shipment and assembly. Each segment is thus 8 ft circumferentially at the "equator," with 24-ft longitudinal edges meeting at the "pole." A full-size replica of one such section was made of wood and plaster, with latitude and longitude lines engraved at 10° intervals for reference in applying topographic details and for decoration. It was lacquered to increase surface smoothness.

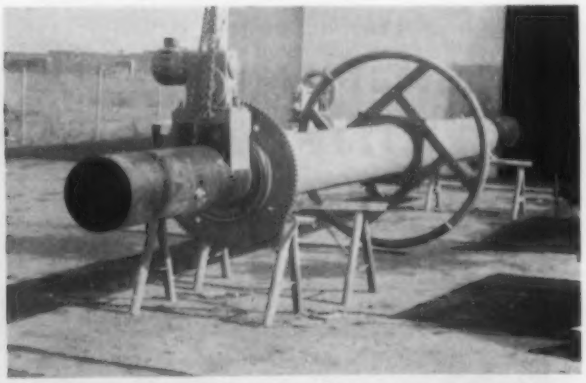
continued, next page

2 **FEMALE MOLD** was formed by laying up the fiberglass-reinforced polyester resin over the model. Wooden cradle on the outside supports the mold, which produced not only the 24 spherical segments, but also the thinner spherical sections from which topographic features were cut. Main sections were molded in ocean-blue color, so the topographic features in other colors stood out. Mold edges have a 3-in. internal step (equator section removable) to form a flange for bolting and inner bracing. Over-all industrial design of the exhibit was, incidentally, done by Henry Dreyfuss, with plastics engineering and installation of the globe by the author.

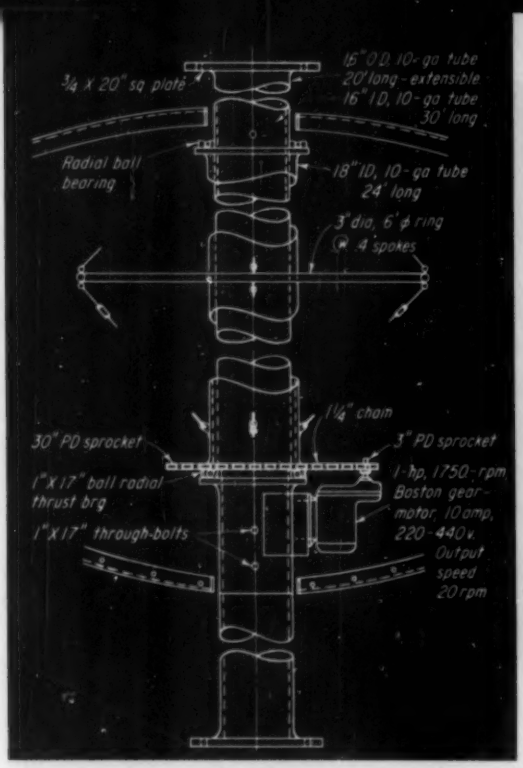
3 **MAIN SEGMENTS** were molded of a commercial resilient-grade polyester styrene resin on a composite woven and nonwoven glass-fiber mat. Average thickness was ¼ in., with flanges ⅝ in. for local stiffness and to allow for stress concentrations at attachment points for bracing wires. Design thickness was based on laminate physical tests yielding 35,000 psi tensile, 27,000 psi compressive, 36,000 ultimate, 2.3×10^6 psi elastic modulus, and 1.5 specific gravity. Each segment weighed 250 lb, was entirely self-supporting. Sheet metal screws held the topographic detail. Individual countries and contours were applied by spray painting in seven colors.



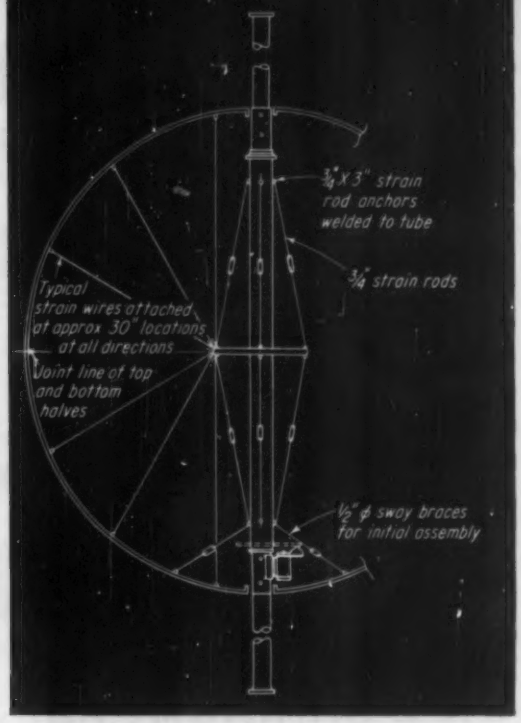
4 **ASSEMBLY** was done by bolting flanges together with ⅜-in. machine bolts and washers on 12-in. centers. Shell weight totaled 6000 lb, while the axis and interior turning mechanism weighed 8000 lb. Strength of the design was dramatically demonstrated during a trial assembly of the upper hemisphere on the ground. Gale winds caught nine sections erected, sheared temporary bolts, and blew sections several hundred yards in all directions. Only two were damaged; they cracked superficially at flanges but were easily repaired. Molded-in color was not damaged.



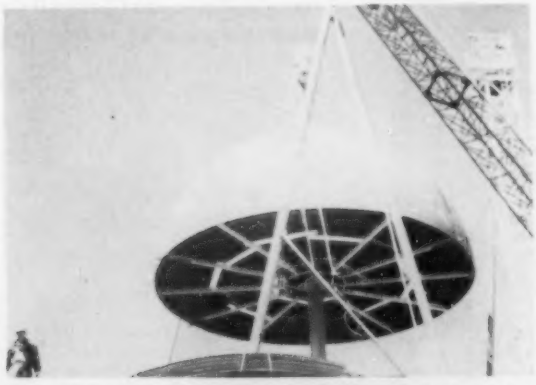
5 **TURNING MECHANISM** was designed around a polar axis. Over this is a larger diameter tube driven by a gearmotor connected by a drive chain to the sprocket on the lower end. The gearmotor is set on a bracket welded to the fixed axis shaft. The sleeve rotates on a 21-in.-dia ball thrust bearing at the bottom and is guided by a top radial ballbearing. Four high-tensile cables on the bottom of the axis and four on top, run to A-frames on the roof, cabled in turn to concrete anchors on the ground. Thus all members except A-frames and axis are in tension only.


¼ X 20" sq plate
15" O.D. 10-ga tube 20' long - extensible
16" I.D. 10-ga tube 30' long
Radial ball bearing
18" I.D. 10-ga tube 24' long
3" dia. 6' ϕ ring @ 4 spokes
1¼" chain
30" PD sprocket
3" PD sprocket
1" X 17" ball radial thrust brg
1" X 17" through-bolts
1-hp, 1750-rpm Boston gear-motor, 10 amp, 220-440 v. Output speed 20 rpm

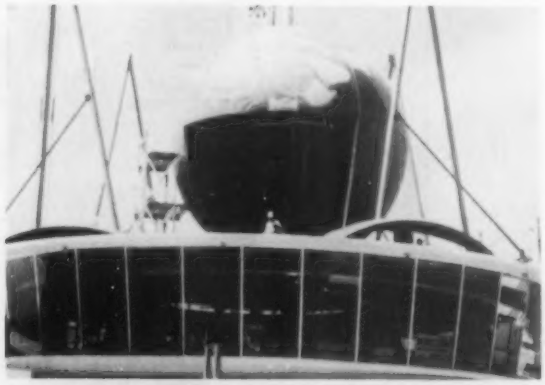
6 **WIRE TENSION MEMBERS** are the sole attaching means from sphere to outer support tube. Design calculations indicated eight wires were required for each of 12 vertical joints from south to north, and 100 wires radially from the support tube to the equator, to support a design load of 6000 lb and wind pressures calculated for 100 mph. These are all No. 9 soft-iron wire. During assembly, it proved practical to use 24 additional lengths of ¼-in. wire rope with turnbuckles to assist in centering. These, along with wood spreaders, were left in place after assembly to raise safety factor from 4 to 6 (not shown).


¾" X 3" strain rod anchors welded to tube
¾" strain rods
Typical strain wires attached at approx 30° locations at all directions
Joint line of top and bottom halves
½" ϕ sway braces for initial assembly

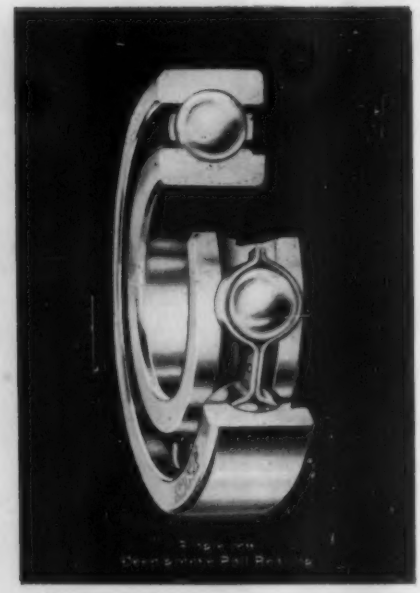
7 **ALL LOAD-CARRYING WIRES** for the top half of the sphere were attached near the top of the turning sleeve and projected radially to the equator and the segment joints at 30° intervals. Bracing cables (shown here at bottom only) were placed at both ends, really acted primarily as sway lines to center the hemisphere. On the lower hemisphere, tension wires from points 30° apart up each flange were were strung to the anchor ring at the center point of the turning sleeve. All this, as well as the turning-sleeve ends and the driving mechanism, was ultimately hidden by the globe itself.



8 **NO ASSEMBLY PROBLEMS** were encountered because a sphere is ideal as a skin-stressed shape. The turning mechanism was set vertically in the center hole of the doughnut-shape building, so assembly of top shell sections could be done at roof level. Segments were bolted together in position, joints covered with white tape to accentuate latitude lines, and topographic features screwed in place. The 2 x 6-in. wood spreaders at the center of each segment provided centering and a later scaffold. Internal support wires were installed, then the assembly lifted for completion.



9 **ALL BUT THREE SEGMENTS** of the bottom hemisphere are in place here. A-frames are also in position and topographic details are on the top half. Each bottom segment was bolted first at the equator, then down the sides, and the final one has a trap at the south pole to allow exit and entry for inspection. Molds and shells were produced in 600 manhours, field assembly required only 350 more, proving the economy of the design. Heavy weather during the exhibit, as well as gale winds, caused no damage, indicating materials and support design were also correct.



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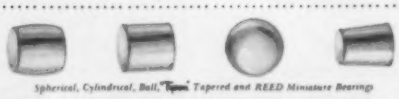
But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

6001



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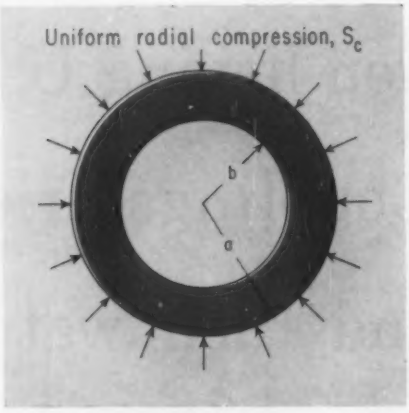
S WARREN KAYE, *Raytheon Co*
Bedford, Mass

Internal supports for tubular structures can greatly increase over-all structure-strength. It is, however, important to know what the critical compressive stress is at which elastic buckling of the support occurs. The *K* factors on this page and the nomograph on the continuing page quickly find this stress value.



Symbols

For uniform radial compression on outer edge of plate

K = factor depending upon radii ratio

S = critical compressive stress at which elastic buckling occurs, psi

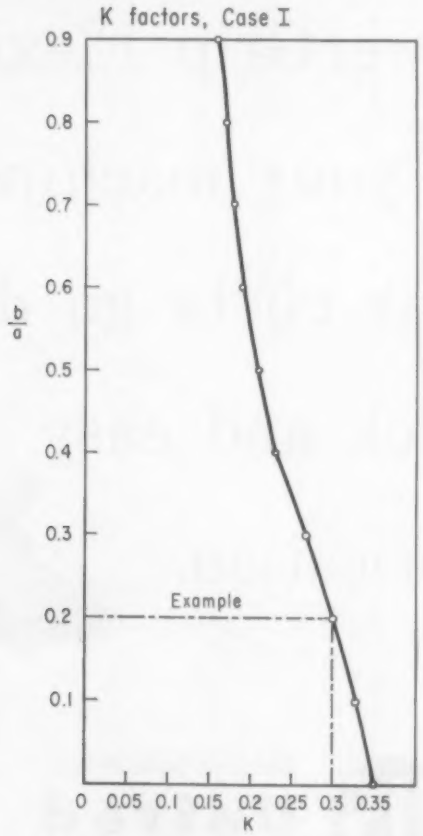
E = elastic modulus, psi

ν = Poisson's ratio (for aluminum = 0.3)

t = thickness, in.

a = outer radius, in.

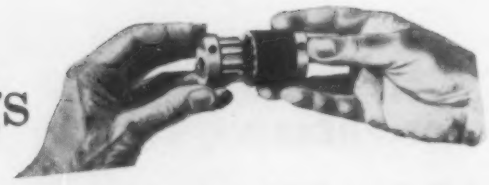
b = inner radius, in.



Case I—Outer edge simply supported, inner edge free.

continued on page 79

US RUBBER **PowerGrip** FLEXIBLE COUPLINGS

These couplings  are so simple in design that their cost is compared with other couplings. Insist on having U. S. PowerGrip Flexible Couplings tried on your machinery and then watch your costs go down. Installation is quick and easy. No maintenance, no lubrication. Call now!

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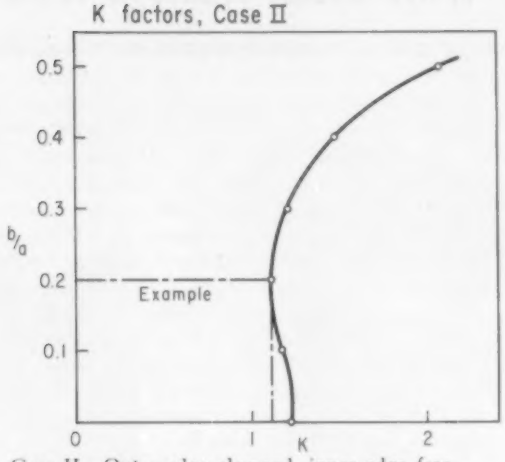
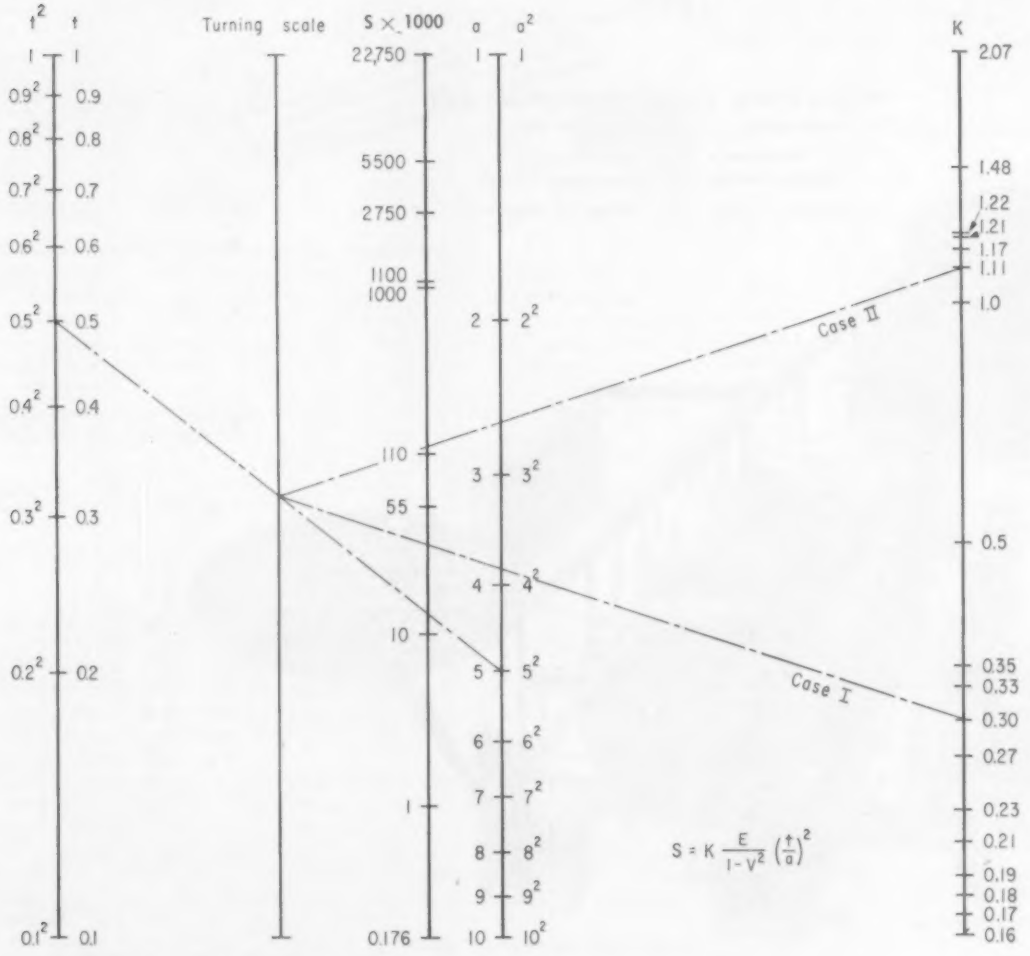
MAXIMUM COMPRESSIVE STRESS for ANNULAR PLATES—continued

EXAMPLE

An annular aluminum plate, 0.5 in. thick, has a = 5 in., b = 1 in.; E for aluminum is 10 x 10^6 psi. From the two curves, for Case I, K = 0.3; for Case II, K = 1.11. From the nomograph, S for Case I = 33 x 10^3 psi; S for Case II = 122 x 10^3 psi.



Case II—Outer edge clamped, inner edge free.



300 HOUSINGS PER HOUR
produced on Greenlee machine—
with assist from VICKERS hydraulics

Here's a Greenlee transfer machine that produces 300 steering gear housings per hour while performing a total of 114 close tolerance machining operations. This outstanding performance record is achieved because the machine combines advanced design ideas with the best available components.

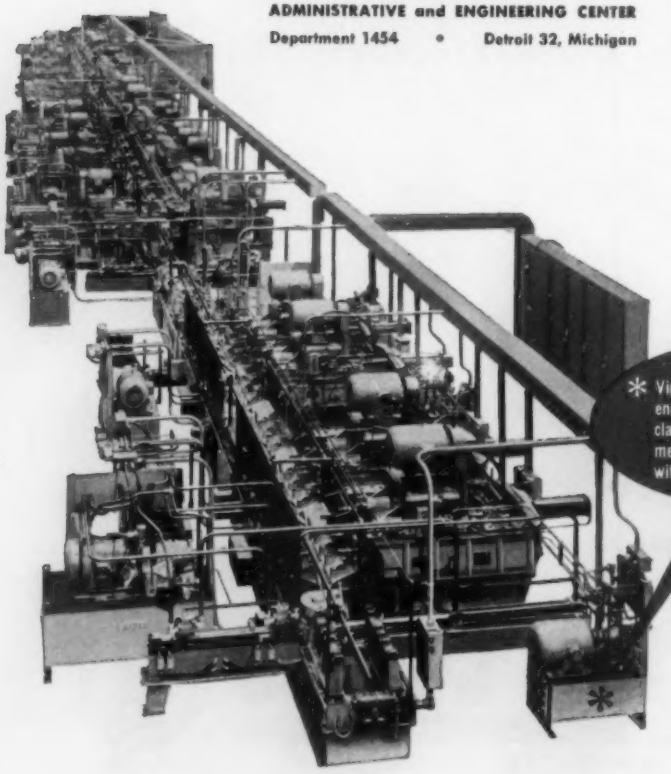
Self-contained Vickers hydraulic power packages provide controlled power for clamping the pallet-mounted workpieces in precise position at each work station, driving transfer mechanisms and for movement of certain machine heads. These power packages are designed to JIC (Joint Industry Conference) standards which means easy maintenance and minimum downtime to you.

Vickers offers you power packages, either standard or custom engineered that provide an almost unlimited number of choices to meet your specific technical requirements. You can choose from the broadest product line in the industry any combination of controls for use with single, double, two-pressure or two-stage pumps (the latter for pressures to 2000 psi), and for variable and constant delivery pumps to 5000 psi. Your choice of components will be packaged with the size or shape reservoir best suited for your job.

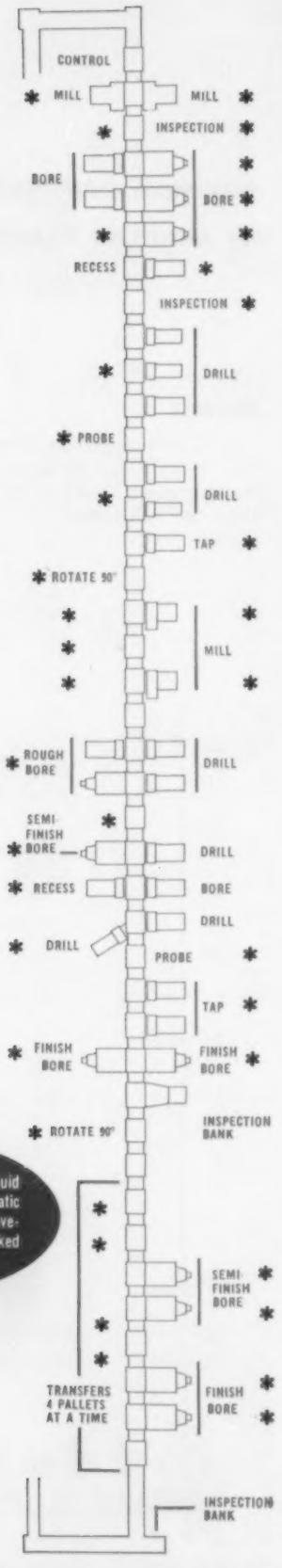
Whether the Vickers power package you choose is standard or custom engineered, you save money and time because it comes *ready-to-go*—designed and assembled to the highest standard of quality by hydraulic specialists.

Get more data by writing today for Bulletin 5001C or by consulting your nearby Vickers application engineer.

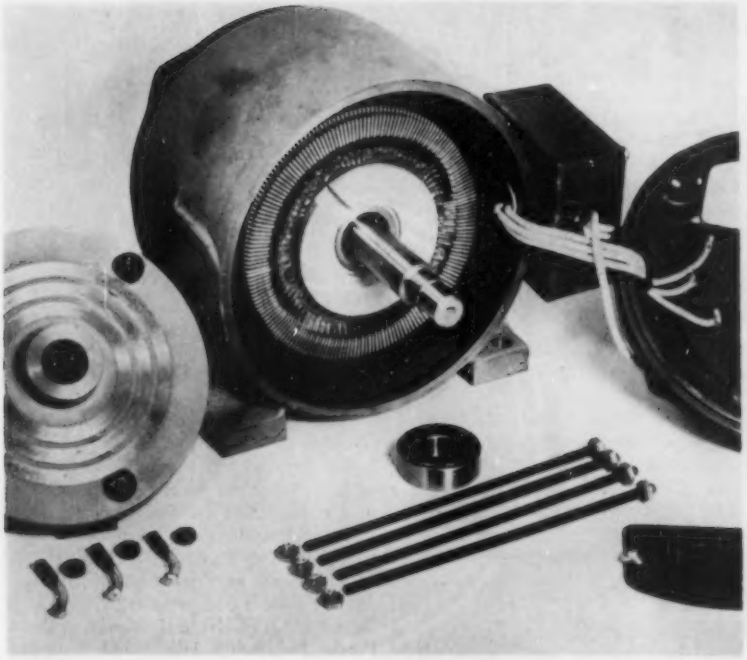
VICKERS INCORPORATED 8514
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan



* Vickers power packages supply fluid energy for fast, precise, automatic clamping, transfer and head movement at station locations marked with asterisk.



SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



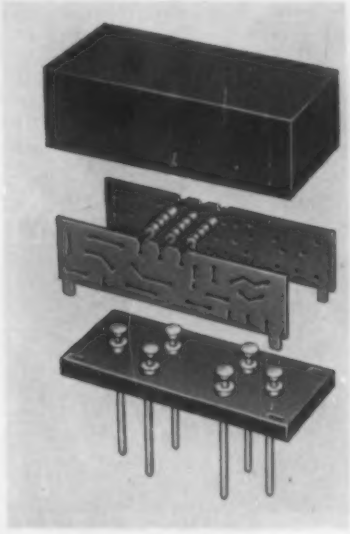
Positioning control uses variable transformer . . .
to provide controlled angular rotation. Operates from single-phase, 60-cps input and is capable of driving positioning motors at torques to 1 ft-lb. Can be driven at speeds from zero to 600 rpm. Positioning motor will follow in exact relation to shaft speed of rotating transformer (shown in exploded view). There is no torque reaction between positioning motor and rotating transformer, so that less than 1 in.-lb torque to transformer will provide torque of to 1 ft-lb from positioning motor. Applicable to tool positioning and to exact synchronization of two or more devices. **B A Wesche Electric Co, 9027 Shell Rd, Cincinnati 36.**

Circle 300 on Reader Service Card

Noise- and vibration-damping material . . .
is reported to control resonant response of structures exposed to high-frequency vibration and wide-band noise. Employs specialized form of elastomer that maintains damping and environmental resistance characteristics in —65 to 250 F. Damping material controls response over broad frequency range, reducing amplification that causes structural failure or malfunction. Structural sections utilizing damping material have resonant amplification of 3 to 5:1.

Available in structural sections or laminated panels or fabricated as damped assemblies. Can also reduce resonant response of electronic equipment chassis and other secondary structures. Laminated panels consist of plies of metal plates with elastomer sandwiched between plates and bonded to them. Weight of typical 20 x 20-in. laminated panel, 1.01 lb per sq ft, is comparable to aluminum sheet. Panels can be punched, sheared and formed by usual stretch-forming techniques. Test samples available for evaluation. **Lord Mfg Co, Erie, Penna.**

Circle 301 on Reader Service Card



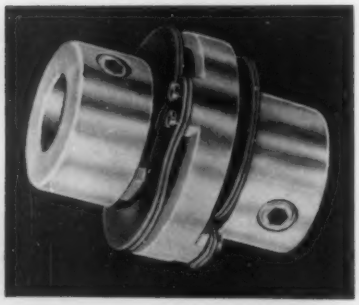
Miniature molded printed-circuit boards . . .
incorporate molded circuit canals and lead holes, according to circuit design. Canals are filled with high-conductivity silver (circuits with gold plating or of copper, which can be nickel- and rhodium-plated, available). Boards, fabricated with epoxy molding compounds, are said to offer high-temperature resistance, high dielectric characteristics, low moisture absorption, high dimensional stability, good mechanical strength and excellent chemical resistance. Standard thickness is 0.050 in.; length and width to specifications. Black is standard color, but brown, red, green and blue are available for color coding. Shapes other than flat boards are possible. Also, circuits and component parts can be molded in any standard potting shell or case for modular packaging. For circuit packaging, epoxy shells and headers with terminal styles and layouts to specification are available. Said to be priced as low as ¼ the price of conventional circuit boards with raised copper-clad circuitry, in many applications. Also said to be inexpensive method for producing flush-type printed-circuit boards, often costing 20% of price of conventional flush-type boards. Tooling costs are also reported to be about ⅓ that of conventional-type boards. Delivery, about 3 wk. **Plastronic Engineering Co, 721 Boston Post Rd, Marlborough, Mass.**

Circle 302 on Reader Service Card

Laminated heating elements

are bonded to part surfaces with thermosensitive adhesive on one surface of strip. It is reported not to soften with heat, water or solvents. Strip is sandwich of dielectrically treated glass cloth, which employs heat dissipating film that provides uniform heated surface. Secondary lamination method permits user to wet resin surface with solvent and apply to part with pressure. Elements are available in stock sizes or engineered to specifications. Delivery, about 2 wk. **Thermo-O-Lab Corp, 6940 Farmdale Ave, North Hollywood, Calif.**

Circle 303 on Reader Service Card



Flexible couplings . . .

offer max torque of 4 to 215 in.-oz and zero backlash. Usable for lateral, axial and torsional deflection applications. Accommodate up to 8° angular misalignment. Weights of 0.10 to 1.60 oz and constant angular velocity suit couplings for high-speed applications where balance and low inertia are essential. Require no lubrication. Coupling materials are aluminum with beryllium-copper leaves. List prices for ½-, ¾-, 1- and 1½-in. sizes range from $13 to $17.50. Delivery, 2 to 3 wk. **Naugler Engineering Inc, 19 Madison Ave, Beverly, Mass.**

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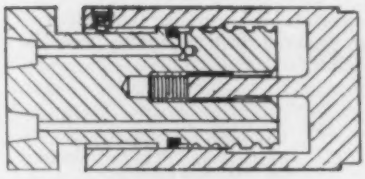


Micrometer flow-control valve

that is linear through 15 turns, is reported to overcome disadvantages of low-flow adjustment and clogging of small passages inherent in needle valves. Viscous passage length is adjusted by micrometer precision screw. Rate of flow in Model F4 valve (illustrated) is increased linearly tenfold through 15 turns, as contrasted to needle-valve types, which may increase flow by factor of 200 to 500 with one turn of adjusting wheel. Flow-passage area in valve is constant. Flow in illustrated model, with Univis 40 oil at 115 F and pressure drop of 100 psi, can be regulated from 10 to 100 cc per min. through 15 turns, equivalent to about 6 cc per min. This model, about 5 in. x 2 in. dia, is priced from $12 to $30, depending on quantity. Other models with similar flow characteristics can be furnished in various sizes. Prices vary from $5 to $50 depending on flow volume and quantity. Delivery, about 4 wk. Valve is particularly adaptable for use as variable damping passage in electrohydraulic servosystems and in conventional on-off systems where water hammer is a problem. **Sanders Associates Inc, 95 Canal St, Nashua, NH.**

Circle 305 on Reader Service Card

Transistorized level control

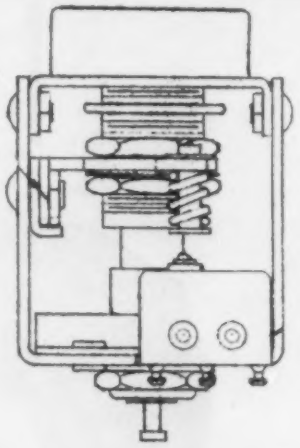
is said to be suitable for high- and low-level detection of liquids, granular solids and liquid/liquid interfaces. Unitized, explosionproof models are standard for operation on 115 v, 60 cps, ac; also available for 12 or 24 v dc. Choice of failsafe or direct action. **Instruments Inc, PO Box 556, Tulsa, Okla.**

Circle 306 on Reader Service Card

Modular speed reducer . . .

(shown in cutaway view) makes possible 20 different ratios by utilizing two or three reducer modules in combination. Basic ratios of 5, 10, 20 and 25:1 can be arranged to provide ratios from 5:1 with a single module to 15,625:1 by combining three modular speed reducers. Units measure 1¾ x 1¾ x 1 in. and weigh 4½ oz. Can be used with wide range of BuOrd servo and other motors. $49.50 each module. Delivery, about 2 wk. **Link Div, General Precision Inc, Binghamton, NY.**

Circle 307 on Reader Service Card



Panel-mounted, pushbutton miniature gang switch . . .

is supplied in from two to 10 switches, locked and interlocked. No two switches can be operated at same time. Any switch that is down must be released before another switch can be operated. Illuminated pushbuttons offer snap-in rebulbing from front. Standard lens is ¾-in. sq button on 1 in. centers. Available in contact ratings to 5 amp at 28 v dc. Said to be reliable for over 100,000 cycles of operation at rated load. Can be furnished in SPST up to 6PDT or any combination thereof. Average price is $18 per plunger, depending on quantity. Normal delivery, 4 wk. **Pendar Inc, Switch Div, 14744 Arminta St, Van Nuys, Calif.**

Circle 308 on Reader Service Card

Solid-film lubricant . . .

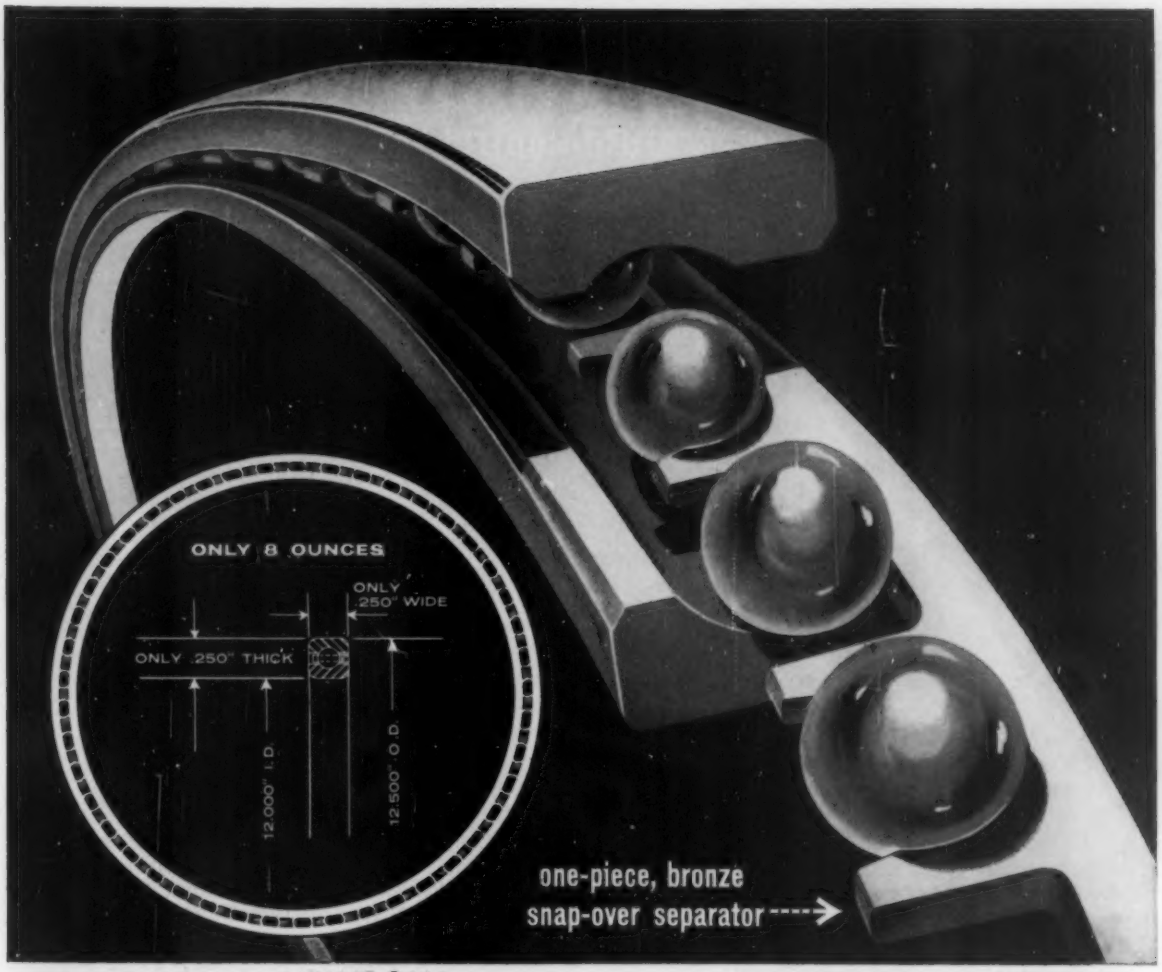
is formulated from molybdenum disulphide with epoxy binder. Does not require any unusual surface pretreatment before application. Applied by such usual methods as spraying, brushing or dipping. Dried film provides permanent lubrication of all types of rotating and sliding bearing surfaces at temperatures up to 750 F. At present, lubricant is formulated in two grades. One requires baking at 350 F. This costs $32.50 per gal, which covers 1200 sq ft. Second grade can be air dried or baked. This formulation costs $17.50 for sufficient lubricant to cover 600 sq ft. Samples offered to letterhead requests. **Poly Chem, 541 S Webster, Indianapolis 19.**

Circle 309 on Reader Service Card

Phenolic molding compound . . .

is asbestos-reinforced and has heat-distortion point of over 500 F. Combines impact strength of 2.5 ft-lb per in. of

continued on page 84



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

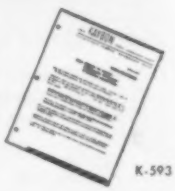
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearings

He's passing the word!

Electrical designers . . . product designers . . . heating specialists . . . the list is almost endless. Men who know temperature control specify Robertshaw . . the name that MEANS—*temperature control.*

For most every heating unit from heat pump to annealing furnace to lab equipment to tobacco curing . . . gas or electric . . . there is a standard Robertshaw temperature control to more than fill your needs. And special designs are no problem.

Temperature ranges: 0 to 800°, wide spread, 50° spread or fixed setting for flat line control—factory set and locked

Power supply: AC to 250v, limited DC if desired

Types: capillary or bulb, up to 140" capillary for remote location

Action: snap or slow make and break, direct or reverse

Amperage rating: to 25A at 250v AC, 15A at 115v DC

Construction: diaphragm—stainless steel;
case—rugged plated non-rust steel

Have a problem? Need design service? Call Robertshaw . . . the name that MEANS temperature control.

VMA 6992

Call or fill in the coupon for information on any temperature control application. Robertshaw Thermostat Division, Robertshaw-Fulton Controls Company, Youngwood, Pennsylvania.

Robertshaw

Gentlemen:
Please send temperature control information for these applications:

Name & Title_____
Company_____
Address_____
City_____ Zone_____ State_____

Mail to: **Robertshaw Thermostat Division**
Robertshaw-Fulton Controls Co., Youngwood, Pa.

notch (average) with compressive strength of 12,000 psi; tensile strength of 6000 psi and compressive strength of 22,000 psi. Mold shrink, 0.001 in. per in. For gears, electrical switchgear and control parts. **Rogers Corp, Rogers, Conn.**

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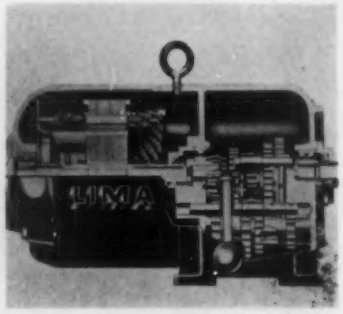


Selective 4- or 8-speed drive

now is available for mounting in any position. Furnished with standard single-speed motors of 1800, 1200 or 900 rpm; with ratings of 1, 1½, 2, 3 and 5 hp. Gear ratio is: low, 4.15:1; 2nd, 3.15:1; 3rd, 1.85:1; high, 1:1. Output speeds with 1800 rpm input are: low, 420; 2nd, 555; 3rd, 930; high, 1730. Furnished to operate on standard current 208, 220 to 440 or 550 v, three or two phase, 60 cps. **Lima Electric Motor Co Inc, Dept 145, Lima, Ohio.**

Circle 311 on Reader Service Card

X-shape aircooled compressor

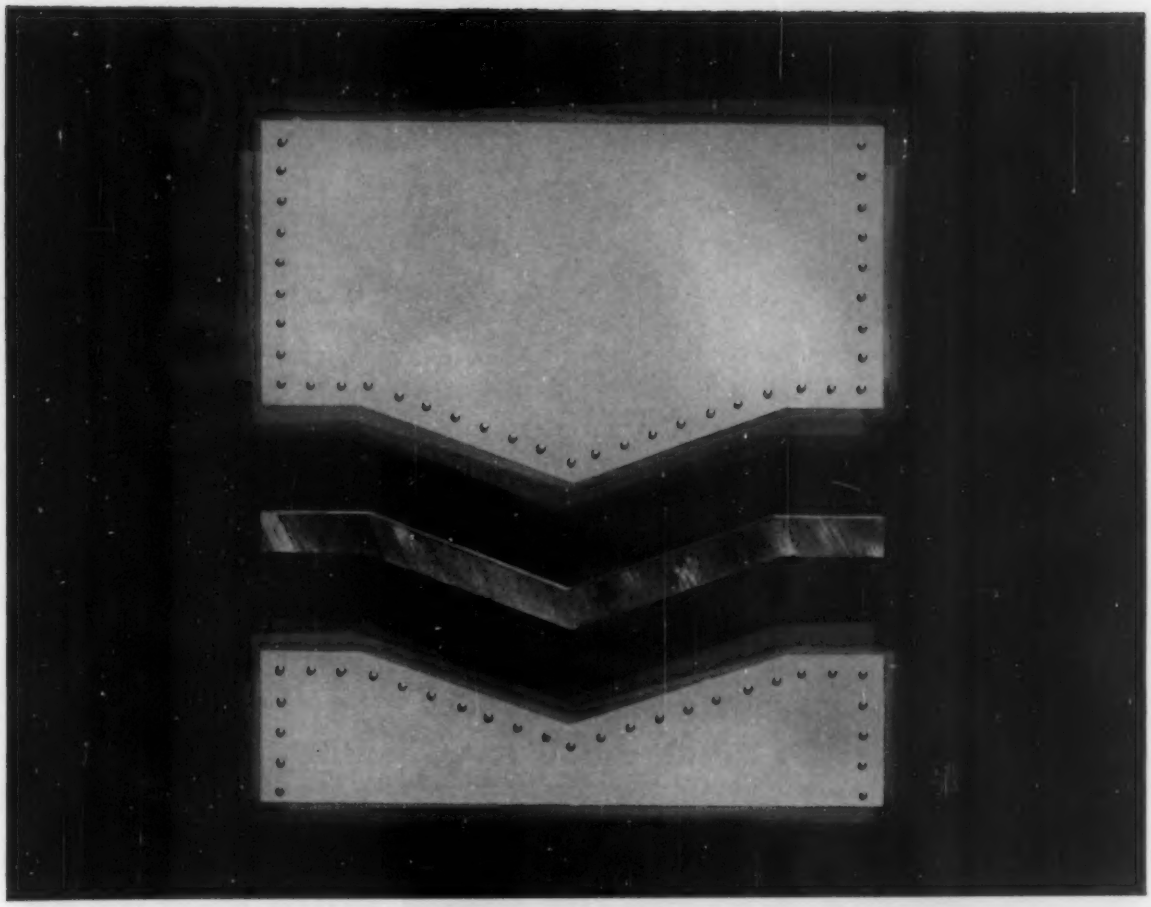
is offered as belt-driven model and also with motor as integral unit. X-shape, achieved by short-stroke design with reduced cylinder overhang and by use of wide-stance base, cuts vibration. In integral unit, motor frame is bolted directly to compressor crankcase, which, in turn, supports motor rotor. Two valve plates and stainless steel valve strips make up entire valve service for each cylinder. Belt-driven compressor is available in ratings from 1½ to 15 hp and pressures from 60 to 250 psi. Integral unit is available in these sizes: 1½, 2, 3 and 5 hp. Motors, designed to meet NEMA B requirements, are for single-phase, 60 cps, 115/230 v or three-phase, 60 cps, 220/440 v. **Worthington Corp, Harrison, NJ .**

Circle 312 on Reader Service Card

Fhp 3-phase ac brake motors

in dripproof and totally enclosed, fan-cooled construction, offer integral, one-piece design. Magnetic brake is used to bring motor to rest and to hold load stationary when motor is deenergized. It is spring-set and solenoid-released and

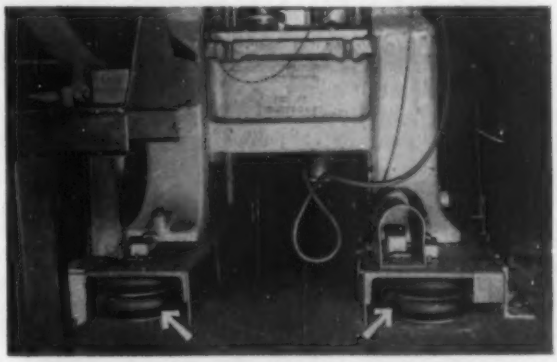
continued on page 86



How to make a pounding punch press "whisper"

Firestone Airmounts® cut vibration and noise 94% in 160-ton-capacity forming press

Before Bethlehem Tool & Mfg. Co., Chicago, installed Firestone Airmounts beneath a 25,000-lb. forming press, seismographic recordings revealed impact vibrations of 11.8 mils on conventional shock pads. *After* Airmounts, these same vibrations registered a tiny *0.7* mils—a total shock reduction of 94%! For Bethlehem, Firestone Airmounts offered a simplified solution that meant more efficient working conditions, reduced machinery maintenance, increased production with consistent quality and drastically lowered impact disturbance for neighboring properties. It has also eliminated the need for conventional shock pad replacement. Is your equipment heavy? Light? Old? New? Powerful? Delicate? Does it change its load radically during operation? Whatever the accompanying vibration concern, whether it involves shock-isolation or actuation, proved Firestone Airmounts offer a low-cost, long-term answer for an increasingly wide range of industrial machinery. Without obligation, write today for full details of how they can serve you.



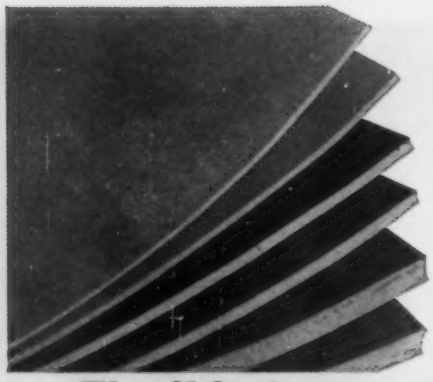
Positioned between press base and concrete floor, Firestone Airmounts provide stable support and are easily adjusted to varying degrees of impact and load.

Firestone

AIRMOUNT® FOR INDUSTRY

Firestone Industrial Products Co., Noblesville, Indiana

CIRCLE 85 ON READER SERVICE CARD 85



SILICONE SPONGE RUBBER SHEETS

Flexible temperature range -100°F to 500°F

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening. Meets many specifications.

AVAILABLE FROM STOCK: in 12" x 12" sheets and 24" x 24" sheets — 1/16" through 1/2". Special thicknesses and sheet sizes up to 30" x 30" and 24" x 48" made to order. Sold nationally through distributors.

FREE SAMPLE and folder — write, phone or use inquiry service.

Leader in Fabrication of Silicone Rubber Products

CHR CONNECTICUT HARD RUBBER CO.

Main office: New Haven 9, Connecticut

CIRCLE 204 ON READER SERVICE CARD

No other terminal block — sectional or one-piece gives you all the advantages of

BUCHANAN

MD sectional pres-SURE-blocks

NO WASTE CIRCUITS—Reduce material costs, save space. Supplied assembled in 20 snap-fit section lengths. Pull off or add groups for any length block.

SMALLER INVENTORY—Only 2 different parts (contact and end sections). No running out of needed items.

MORE CIRCUITS IN AVAILABLE SPACE—Increase contact capacity, decrease jumpering. Group common wires (equivalent to 1 #22 thru 1 #8) in tubular contacts. Contacts on 7/16" centers. 10 circuits 4 7/16", plus 21/32" for each complete block.

NO TERMINALS OR LUGS—Eliminate lugging costs. Tubular contacts provide secure, efficient connections.

NO HIDDEN CIRCUIT MARKINGS—Unobscured top marking area minimizes errors. Integral or separable strips.

QUICKER TO INSTALL AND CHANGE—Hand assembled, no fixtures or hardware. Mount only every 12 sections. Add circuits without removing mounting screws.

LOW INSTALLED COST—Competitive with conventional blocks of similar rating.

Separate Sections or Factory-Assembled Blocks
Flat Base or Channel Mounting • Tubular or Strap-Screw Contacts
Fanning Strips • Conservative 750-volt A.I.E.E. rating

Tubular contacts fully approved by U.L. Blocks fully approved for 600 V by C.S.A.

Write for Bulletin PE-3

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New York–Mar. 21-24

BUCHANAN
ELECTRICAL PRODUCTS CORPORATION
HILLSIDE, NEW JERSEY

will set automatically in event of power failure. Brake torque is 3 lb-ft continuous. Available in sizes from 1/4 through 3/4 hp. All models are rated 208 to 220/440 or 550 v; 1725 or 1425 rpm. Dripproof model is rated 60 or 50 cps, 40/58 F rise. General Electric Co, Schenectady 5.

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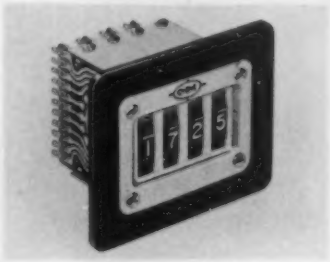

Digital switch assembly . . .

contains 1 to 16 thumbwheel switches in 8, 10 or 12 positions with instant numerical readout. May be positioned horizontally or vertically with engraved numbers or designations to suit. Available with replaceable printed-circuit wafers or with fixed wafers. Immediate delivery on standard units. Prices range from $2.27 to $5.58 per module. Chicago Dynamic Industries Inc, Precision Products Div, 1725 Diversey Blvd, Chicago 14.

Circle 314 on Reader Service Card

Single- and double-worm gearmotors . . .

are offered with shaft outputs of 10 to 750 rpm. First worm cuts directly on motor shaft. Shaft worm and secondary worm case hardened for max life. High-speed first gear is fibre for min. noise; low-speed gear is bronze for max torque. Shaft position can be changed to six 30° positions by six screws. Over-all size is 6 x 3 5/8 x 3 3/4 in. high. Weighs about 5 lb. Available as universal, shunt or series motors from 12 to 220 v input. Carter Motor Co, 2700 W George St, Chicago 18.

Circle 315 on Reader Service Card

Ac-dc contact-making wattmeter . . .

can monitor product of as many as four different variables. Main elements are locking-contact meter-relay and magnetic circuit built around Hall-effect solid-state device. Come in panel-mounting package with 4 1/2-in. meter and barrel less than 5 in. long. Greatest standard full-scale sensitivity is, at present, 500 million, ac or dc. Instrument eliminates standard dynamometer movement of wattmeters because Hall device puts out voltage proportional

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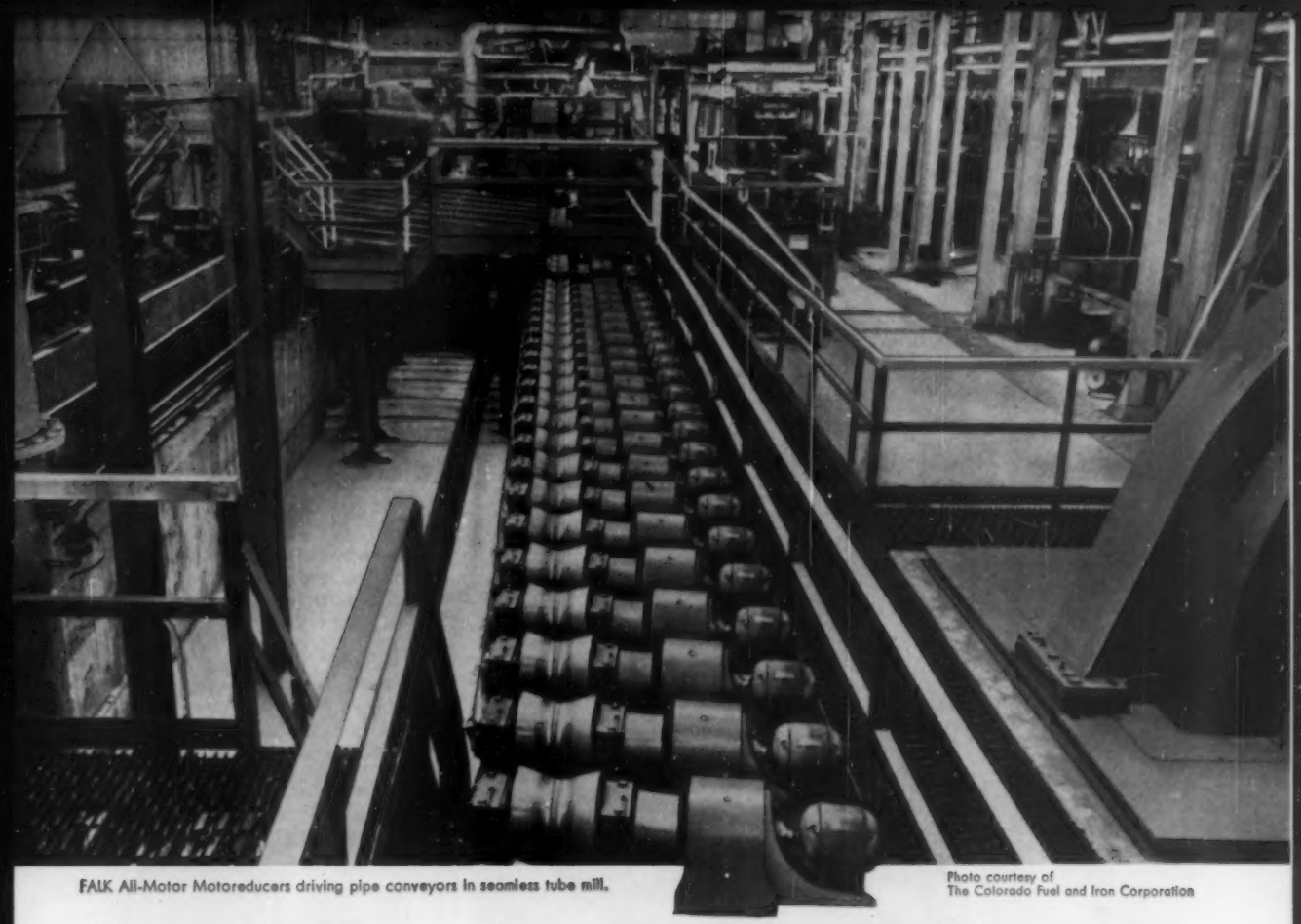


FALK All-Motor Motoreducers driving pipe conveyors in seamless tube mill.

Photo courtesy of
The Colorado Fuel and Iron Corporation

You get these "extras" when you buy FALK *all-steel* Motoreducers

1. **Freedom from damaged housings.** The exclusive FALK *all-steel* construction gives full protection from cracked housings or torn-off feet...plus twice the ability of cast iron to maintain vital alignment.

2. **Inherently stronger gear teeth.** By AGMA standards, Falk extra-depth, high pressure angle helical gears are inherently stronger than ordinary helical teeth, thus assuring reliable operation and longer gear life.

3. **Highest known gear efficiency**—98½% per gear mesh under full load! This means maximum productive work for your power dollar.

4. **Longer service life**...advanced FALK design makes it possible to machine both bores for each shaft assembly at one time, thus eliminating possible accumulation of tolerances that occurs when individually machined parts are assembled. The result—better alignment of revolving elements that permits units to transmit rated capacity longer.

5. **Standard units to fit your needs.** Integral and All-Motor® Motoreducers are available in horizontal, vertical and right angle types...a type for every use.

Units are available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Prompt delivery from factory, warehouse or distributor stocks. Ask your FALK Representative or Authorized FALK Distributor for *Bulletin 3100*.

THE FALK CORPORATION, MILWAUKEE 1, WIS.

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

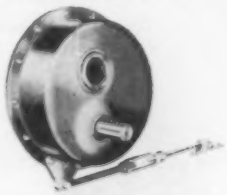
Representatives and Distributors in most principal cities

FALK

...a good name in industry

THE FALK ALL-MOTOR® MOTOREDUCER
the original All-Motor unit

(Shown) Horizontal concentric model. Also available in right angle and vertical types.

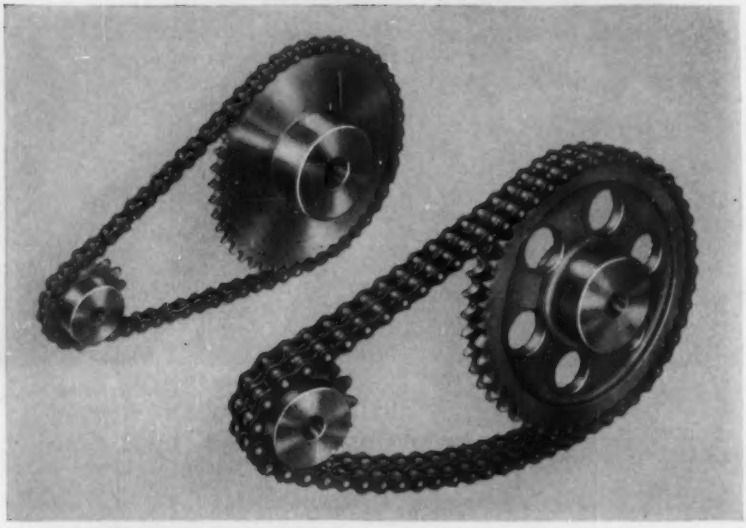


THE ALL-STEEL FALK® SHAFT MOUNTED DRIVE

Proved best for the countless industrial applications where a reducing unit mounting directly on shaft of the driven machine is indicated.

Units from 1/2 to 50 hp. Ratios —4:1, 14:1 or 24:1. Torque capacity up to 41,000 lb-in (in standard units). Prompt shipment from stock. For details, ask for *Bulletin 7100*.

DO YOU HAVE THE PROPER CHAIN SELECTION FOR YOUR EQUIPMENT?



If there is a question in your mind about the correct size of chain to use for your particular installation, save time and money by consulting ACME Engineers at once. They will assist you in selecting the proper chain drive. In many instances, this depends on how much horsepower you want to transmit . . . the speed and size of your shaft . . . space limitations . . . hours of continuous operations, etc.

These are problems on which our engineers can draw from their many years experience to give you the correct answers.

Consult your nearest ACME Distributor or write our Engineering Department for the answer to your CHAINING PROBLEMS.

Write Dept. I-M for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

to power in load circuit. Available with any standard circuits used with locking contact meter-relays. **Assembly Products Inc, Chesterland, Ohio.**

Circle 316 on Reader Service Card

Vinyl and styrene polymers . . .

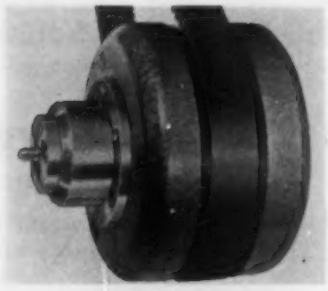
in the form of highly oriented fibers are available in developmental quantities. Fibers, which vary from very short to $\frac{5}{16}$ in. max. in length, are irregular in shape with 2 to 200 micron dia. **Union Carbide Plastics Co, 420 Lexington Ave, New York 17.**

Circle 317 on Reader Service Card

Sub-fhp worm-drive gearmotor

is two-pole, shaded-pole, ac induction motor. Available in 6 to 220 v, 50 or 60 cps. Can be designed for continuous or intermittent operation. Offers output of $\frac{1}{4}$ to 300 rpm. Output torque ranges to 50-in.-lb at $\frac{1}{2}$ rpm. Available output shaft dia are $\frac{5}{16}$, $\frac{1}{4}$, $\frac{3}{16}$ and $\frac{3}{8}$ in. **Molon Motor & Coil Corp, 3739 Industrial Ave, Rolling Meadows, Ill.**

Circle 318 on Reader Service Card



Variable-speed pulleys . . .

rated for motors of 1, $1\frac{1}{2}$, 2, 3, and 5 hp at 1750 rpm and for $\frac{1}{3}$- to $3\frac{1}{2}$-hp motors at 1150 rpm, utilize narrow V-belts and provide speed ratios of 3:1. V-belts range from $\frac{5}{8}$- to $1\frac{7}{8}$-in. top widths. Depending upon pulley model, standard bore sizes are $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1 and $1\frac{1}{8}$ in., with bore lengths from $2\frac{1}{4}$ to $3\frac{5}{8}$ in., and motor travel for full speed range of $3\frac{1}{8}$ to 4 in. Five new variable-speed pulleys, including adjustable motor bases, V-belts and V-belt sheaves are now available from stock. **Hi-Lo Mfg Co, Div of Lovejoy Flexible Coupling Co, 4906H W Lake St, Chicago 44.**

Circle 319 on Reader Service Card

Polypropylene rod, cylinders

are available from stock in 2- and 4-in. rods, $\frac{1}{2}$ through 3 in. dia; cylinders 4 and 6 in. OD x 2 in. ID. Prices range from 60¢ to $27.75 per ft, depending upon

continued on page 92

CELANESE MATERIALS REVIEW

- FORTIFLEX linear polyolefins
- FORTICEL cellulose propionate
- ACETATE molding compounds
- ACETATE sheeting
- POLYESTER resins

CELANESE TECHNICAL SERVICE

How to put more experts on your team without extra cost

Celanese has the technical experts who can help you get the most out of plastic materials at any stage from design to final product testing. Here's a rundown on the technical services Celanese can provide with respect to molding.

DESIGN CONSULTATION

In the final stages of a design, you can call on Technical Service to review the design from the standpoint of molding technology. At this point it is possible to forestall problems of moldability and strengthen critical points by simple means such as changing a radius—without affecting basic design.

ASSISTANCE WITH MOLD DESIGN

Celanese Technical Service is prepared to review mold designs and offer recommendations. This includes mold cooling, gate location, sizes of gates and runners, etc. It's surprising how much a slight variation from optimum in mold design can affect the quality of the molded piece. Form retention, surface quality, freedom from warping and sinks, demand a precise knowledge of the geometries involved as well as of the materials.

MATERIAL SELECTION

Literally dozens of basic formulations of the Celanese plastics exist, and new formulations are possible to meet the needs of molders. They vary in melt index, flow temperatures, molding properties, and end-use properties. Often, formulations are available for special needs, such as flame retardant or light stabilized properties. Here Celanese technical assistance is invaluable in coming up with formulation recommendations that will be most suitable for your product.

EQUIPMENT AND ITS ADAPTATION

Celanese Technical Service will be glad to discuss your equipment requirements or needed modifications. For example, you may benefit from their knowledge of auxiliary molding equipment, or cooling processes, or the details of molding machinery.

PILOT MOLDING SUPERVISION

Celanese technical experts will help you supervise the first run of material. If material difficulties arise at the molding trials, they will make suggestions for changes and cooperate with you on additional trials. If you desire, they will send samples of the molded parts to Celanese Service Laboratories for evaluation.

This service is available to you now. It can help you avoid pitfalls and save you time and money. For further information, check the coupon.

RUGGED, ECONOMICAL MOLDINGS ARE MADE OF CELANESE FORTIFLEX

SILVERWARE CYLINDER FOR DISHWASHER

TOILET SEAT HINGE

CONTAINER FOR VAPORIZER

SEND FOR THE NEW FORTIFLEX DESIGN BROCHURE. Gives detailed property and application data on Fortiflex and many suggestions for its use in industrial design. Shows Fortiflex Plastic used to make injection moldings, blow moldings, high-tensile filaments. Write today! Celanese® Fortiflex® Forticel®

Celanese
PLASTICS and RESINS

CELANESE PLASTICS COMPANY, a Division of Celanese Corporation of America, Dept. 103-C.744 Broad St., Newark 2, N. J.
In Canada: Canadian Chemical Company, Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., N. Y. 16

☐ Please send me "Designing with Fortiflex"
☐ Please get in touch with me regarding Technical Service

Name_____

Title_____ Company_____

Address_____

HOW A SINGLE SOURCE SOLVES YOUR PRODUCTION PROBLEMS

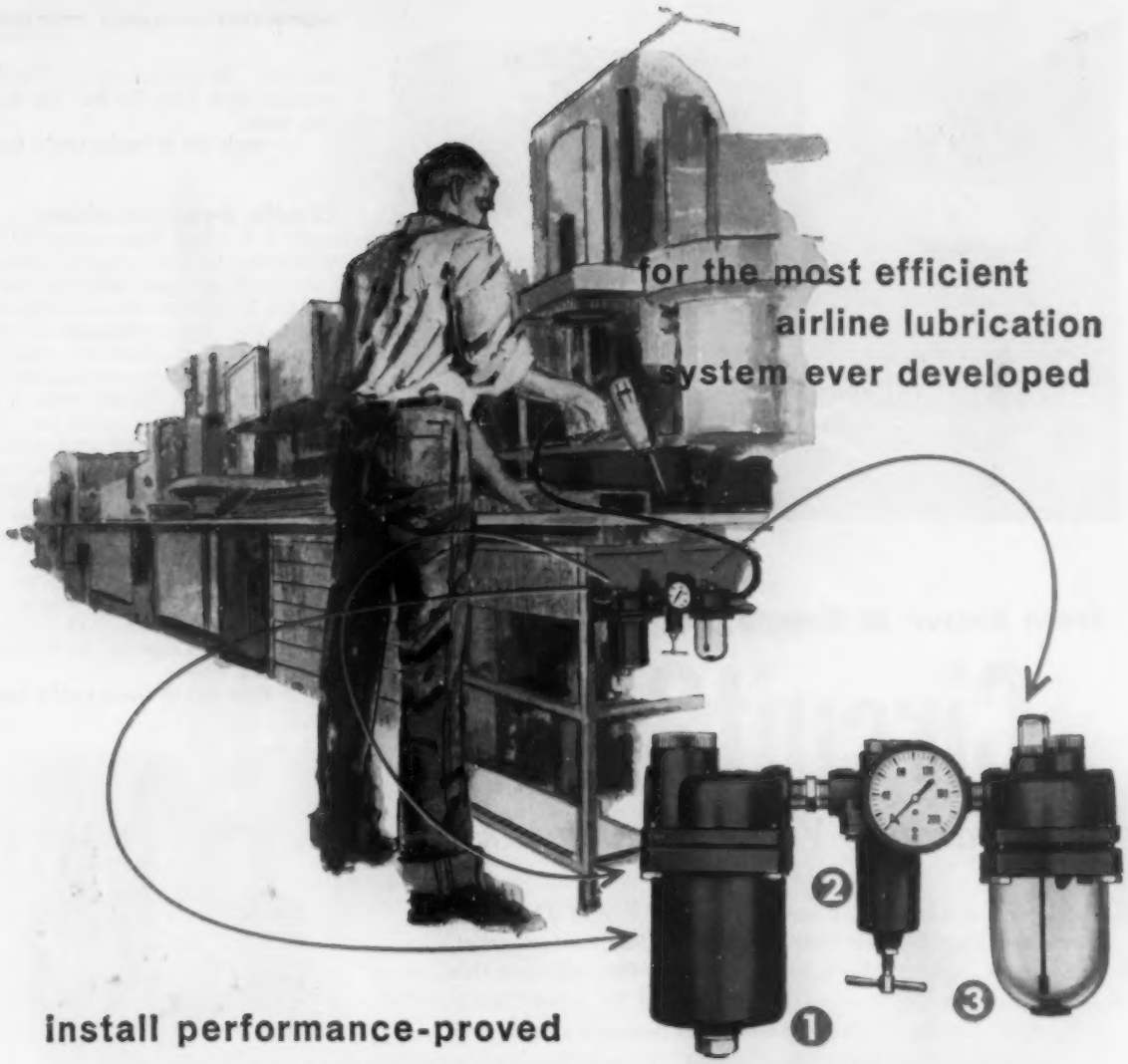
DIE CASTING
NEW DURA-PLATE ELECTROPLATING
METAL STAMPING
POLISHING-PAINTING
ANODIZING

Simply funnel your "specs" into the hands of Brown-Lipe-Chapin and you'll automatically eliminate costly, time-consuming piecemeal orders to crowds of suppliers! B-L-C is equipped to take over your complete production . . . lock-stock-and-barrel. We form metal parts—die cast, pressed, rolled or stretch bent—then polish, plate, anodize, paint and ship them for you from either of our plants at Elyria, Ohio, or Syracuse, New York. B-L-C's diversified facilities provide a single source to give you superior economy, quality, on-the-button scheduling from initial tooling to final shipping. What's more, B-L-C's skilled engineers closely supervise your job from the design stage to finished product, to give you satisfaction in every detail! Call or write Brown-Lipe-Chapin, Syracuse, New York.

GM GENERAL MOTORS

RELIABILITY by BROWN·LIPE·CHAPIN

DIVISION OF GENERAL MOTORS CORPORATION



install performance-proved

ALEMITE "TRI-DUTY" AIRLINE CONTROLS

Complete Alemite package assures cleanest, driest, best-regulated lubrication of air tools, air cylinders, air motors, and many other types of air-operated equipment. Specifically designed for extensive service life and peak efficiency under adverse operating conditions!

❶ **Automatic Water Separator.** Removes all of condensate, all the time. Traps dirt particles to prevent damage to sensitive airline devices. Handles all airline pressure up to 200 PSI and flow volume from 5 to 50 CFM.

❷ **New Air Regulator with Gauge.** Assures accurately controlled air—prevents erratic operation and damage to equipment. Design permits inlet pressures of 250 PSI—adjustments up to 125 PSI. Excess air pressure "bleeds off," within regulator, instantly.

❸ **Automatic Airline Lubricator.** Compensating ball valve design controls air flow. Oil particles are atomized for most efficient transmission through supply lines. Result—uniform mixture regardless of air pressure and volume. Oil and air mixture proportionately constant. Reservoir may be filled at any time, assuring continuous operation. Nine-ounce capacity.

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

1850 Diversey Parkway, Chicago 14, Illinois

Mail coupon for full details!

Alemite, Dept. AA-30
1850 Diversey Parkway, Chicago 14, Ill.

Please send me all the facts about Alemite's new "Tri-Duty" Airline Controls.

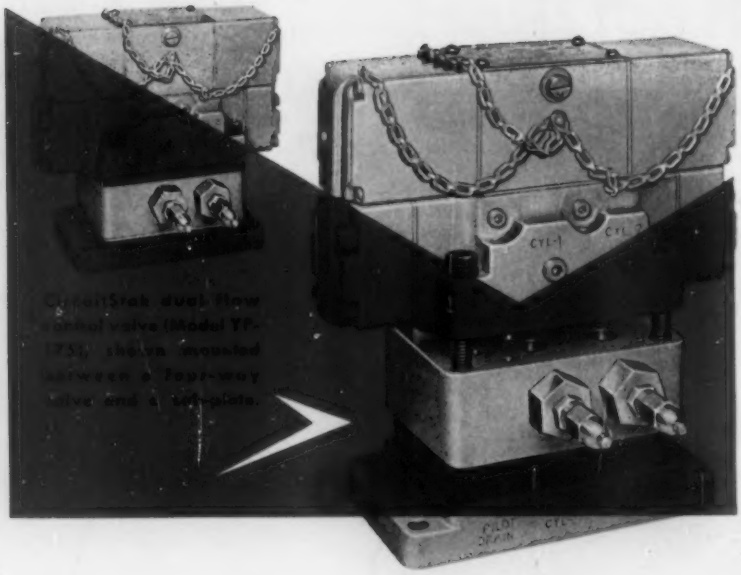
Name .....

Company .....

Address .....

City ..... Zone ..... State .....

CIRCLE 91 ON READER SERVICE CARD 91



From Brown & Sharpe/Double A—

CircuitStak®

Hydraulic Valve Components

The name CircuitStak covers a whole line of Double A valves. They perform functions such as flow control, relief, reducing, bypass, check, and unloading. They all have this in common: they are placed in a circuit by being "sandwiched" between two other valves, or between a valve and sub-plate.

In themselves, CircuitStak valves require no piping. In new circuits they drastically reduce the size of the valve panel. In existing circuits they can be added without any piping or panel change. They are compact, cost less to use, are from every point of view a sensible, logical valve development. Contact your local Double A hydraulic distributor. Or write to **Double A Products Co.**, a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Michigan.

Brown & Sharpe
HYDRAULICS DIVISION
GEAR, VANE & CENTRIFUGAL PUMPS
DOUBLE A VALVES
GEROTOR PUMPS
POWER UNITS
PROGRESS IN PRECISION FOR OVER 125 YEARS

GET COMPLETE INFORMATION on Double A CircuitStak valves
ASK FOR The CircuitStak Folder

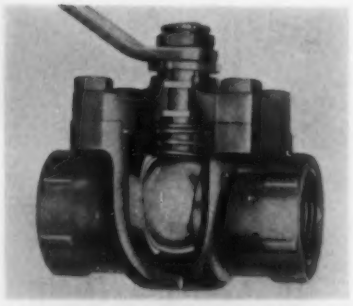
diameter. Withstands up to 240 F. **American Agile Corp, PO Box 168, Bedford, Ohio.**

Circle 320 on Reader Service Card

22-pole, 2-position selector . . .

weighs 2 lb, 1 oz. Meets MIL-E-5272A specifications for shock, vibration, extreme temperatures, salt spray and acceleration. Enclosed in container with atmosphere of dry nitrogen. Current at rated coil voltage is 3.5 amp. Normal rated voltage is 28 v dc. Approximate switching rate is under 30 millisec. Contact rating is ½ amp resistive at 110 v ac, 2½ amp resistive at 28 v dc. Rated for ½ million steps min. Switch can meet vibrations of 2000 cps at 10 g; shock of 30 g min for 11 (±1) millisec; operating temperatures of −67 to 176 F; corrosion 50-hr salt spray and outside humidity of 95% (±5%) RH at 120.2 F for 48 hr. Prices range from $178.35 for 1 to 9 units to $108.95 for 100. Delivery, 2 wk for 1 to 9 selectors. **G H Leland Inc, 23 Webster St, Dayton 2, Ohio.**

Circle 321 on Reader Service Card



Ball valves for up to 350 F . . .

are available in one type for service up to 700 psi, which offers two-way flow, min pressure drop, self-adjusting seals, back-seated stem seals, top entry for in-line maintenance, non-cycling, non-torsional, non-corrosive spring and no lubricant; another type for up to 1000 psi. Pressure may be applied from either side. Valve sizes range from ¼ to 6 in. in screwed or flanged end connections. **Hills-McCanna Co, 4600 W Toughy Ave, Chicago 46.**

Circle 322 on Reader Service Card

Variable transformers for 240-v . . .

single-phase input is offered in model rated 3 amp, which will deliver at max setting 240 v line voltage or 280 v overvoltage; or no-overvoltage model, which delivers just line voltage at max setting, but offers output rating of 4 amp. Both

continued on page 97

DISPLACEMENT
Models 580 (top) and 581 (bottom)

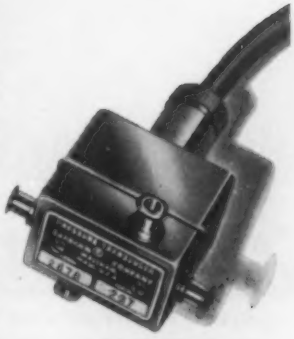
VELOCITY
LVsyn

DISPLACEMENT
Linearsyn

Precision Transducers FROM SANBORN

Linear motion transducers available from Sanborn Company now include the compact, ready-to-use flange-mounted *Model 580* and threaded *581* "probe-styles" for displacements as small as 0.00002" . . . thirty models (shielded and unshielded) of the rugged *Linearsyn* differential transformer for strokes from ±0.005" to ±1.0", displacements as small as 0.000001" . . . and twelve models of the *LVsyn* for producing a DC voltage proportional to a linear velocity. Features of the *580—581* probe-style units include 0.5% linearity; basic sensitivity at 2400 cps of 2.4 volts output / inch displacement / volt excitation; built-in output level adjustment, phase shift and temperature change compensation; carbide-tipped stainless steel contact rod riding in jeweled bearings. Both the *LVsyn* and *Linearsyn* transducers are extremely durable units, immersible in working fluids, introduce little or no friction, and have infinite resolution. Standard Linearsyn coil lengths range from 0.564" to 6.88", LVsyn coil lengths from 3.16" to 22.75".

For differential and single-ended pressure measurements, *Series 267 and 268* transducers for operation in a carrier system offer sensitivities of 40 uv/mm Hg / volt excitation and 40 uv / 0.1 mm Hg / volt excitation. Compact, Monel cases have standard Luer connectors.



PRESSURE
Series 267, 268

Contact your local Sanborn Sales-Engineering Representative for bulletins containing complete facts or write the Sanborn Industrial Division in Waltham. Sanborn Sales-Engineering Representatives are located in principal cities throughout the U. S., Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

At I.R.E. Show Booths 3601-03-05.

for long stroke, high pressure, high temperature requirements . . .

. . . special-order LVsyn and Linearsyn displacement transducers can be supplied. Strokes up to 20" are possible . . . pressure ratings up to 5000 psi, when transducer is submerged in a high pressure medium . . . operating temperature ranges as wide as −65°F to +450°F. Consult factory, stating your requirements.

WHO MAKES FINE MOTORS THIS SMALL?

Globe Industries makes motors this small to make your design more compact, reliable and salable. If you make miniature instrument packages for space exploration — if you build airborne and ground support equipment — if you want to design smaller typewriters, computers, recorders or other products, look at these 3 motors:

TYPE VS—The smallest, most powerful precision miniature d.c. motor for its size. Only 7/16" flat, four VS motors fit in a regular cigarette pack with room to spare. It has the power to lift its own weight to the top of the Empire State Building in 1 minute! Typical continuous torque—.25 oz. in.; typical intermittent torque—.5 oz. ins. We can design gear units, governors and brakes to meet MIL specs also.

TYPE SS — Only 7/8" in diameter, Type SS d.c. motors typically produce continuous duty torques of .3 oz. in.; intermittent torques to .6 oz. ins. With the basic Type SS motor you can specify any of 21 planetary gear speed reducers or 28 spur gear speed reducers. Governors and brakes are available also. Designed to meet MIL specs.

TYPE MM — The most widely used precision 1¼" d.c. motor in the world, MM motors typically produce .5 oz. in. in continuous duty applications — 1.0 oz. in. intermittent duty. Choose from 101 ratios of planetary gear speed reductions. Brakes, governors and clutches can be included. MIL specs are invited.

For details about these motors request Bulletin VSM. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

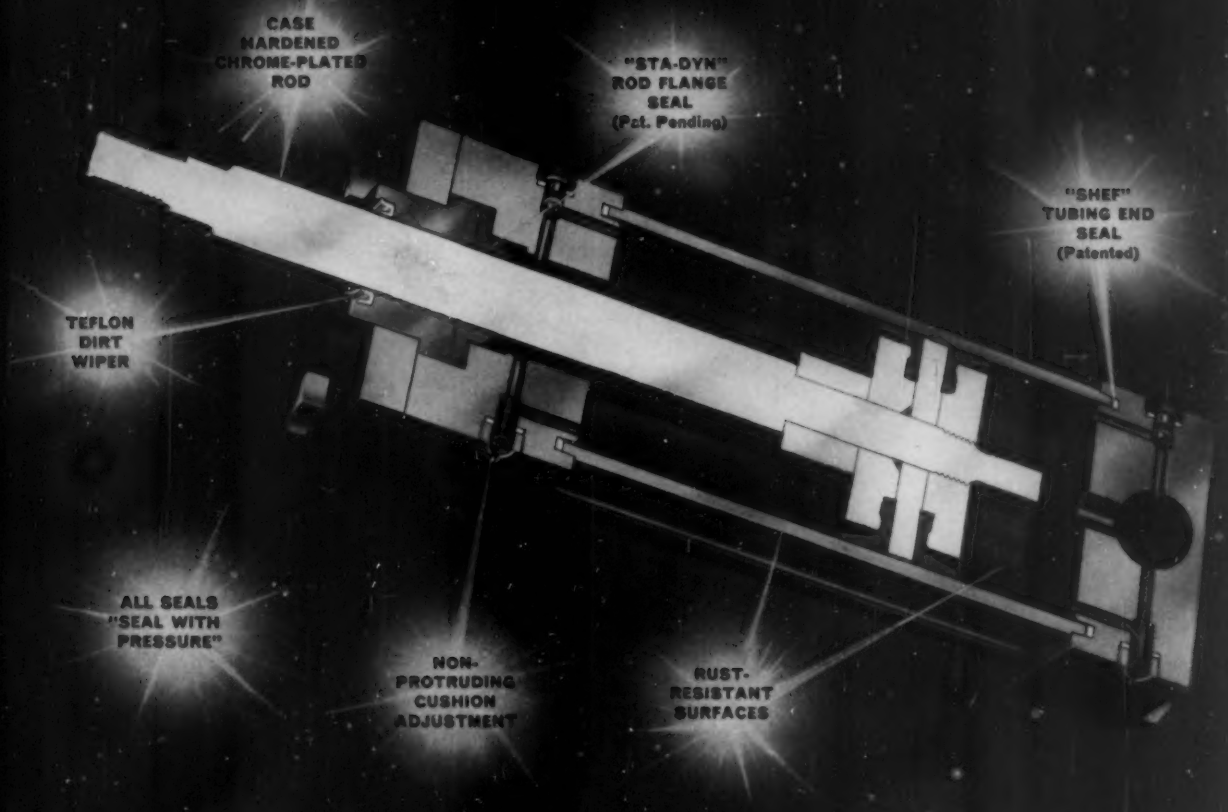
GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. GYROS. STEPPERS. BLOWERS. MOTORIZED DEVICES

GLOBE

CIRCLE 95 ON READER SERVICE CARD→

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

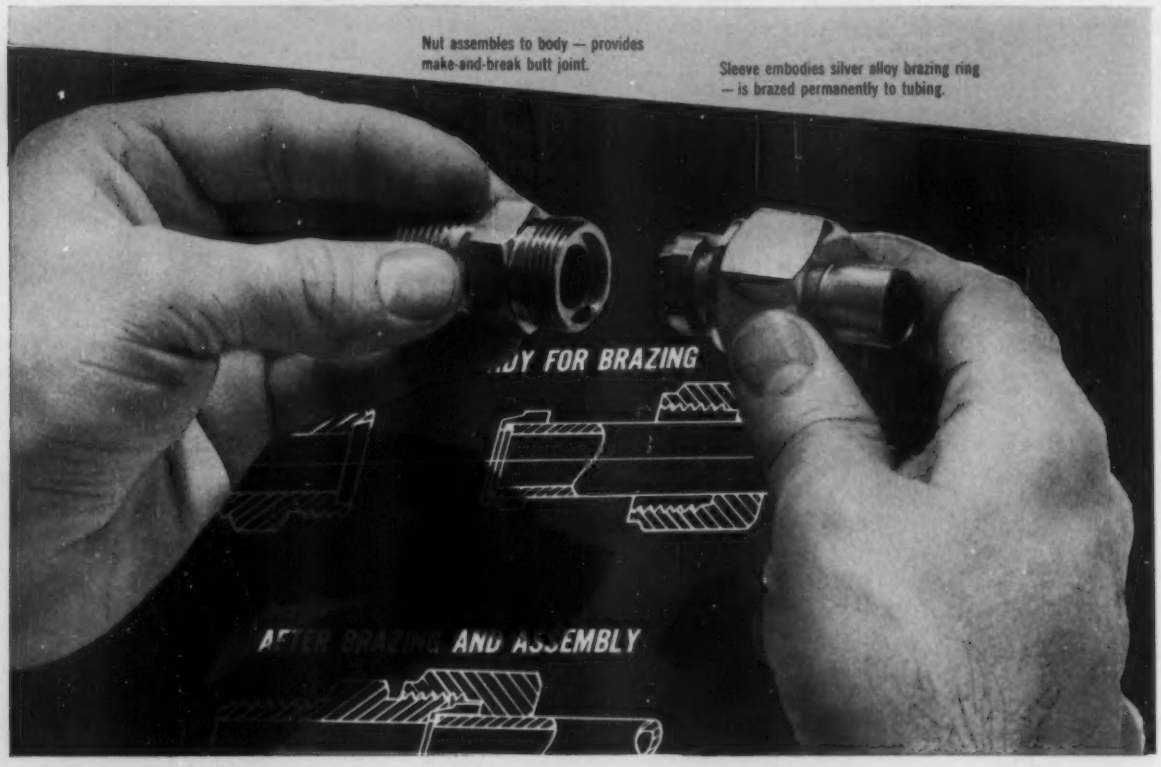
Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

MILLER FLUID POWER

7N018 York Road, Bensenville, Illinois

IMPERIAL
Engineering and Data File


Nut assembles to body — provides make-and-break butt joint.
Sleeve embodies silver alloy brazing ring — is brazed permanently to tubing.
FOR BRAZING
AND ASSEMBLY

NEW BRAZE-SEAL TUBE FITTING

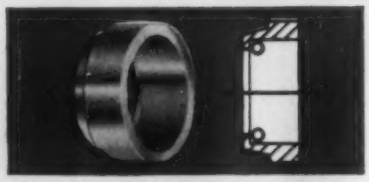
WITHSTANDS SUPER-PRESSURES, HIGH TEMPERATURES . . . RETAINS MAKE-AND-BREAK CONVENIENCE

Until Imperial Braze-Seal came along, engineers could not specify an economical make-and-break fitting for tubing circuits involving super-pressures and high temperatures. Applications like these called for welded connections. But now Braze-Seal offers high reliability, even under extreme pressures. (See chart below.)

MAXIMUM DESIGN PRESSURES (PSI) FOR BRAZE-SEAL FITTINGS

Tube O.D.	316 Stainless	Carbon Steel
3/8"	64,000	48,000
1/2"	62,400	46,800
9/16"	61,600	
5/8"	61,600	46,200
3/4"	60,000	45,000
7/8"	56,000	42,000
1"	52,000	39,000
1-1/4"	48,000	36,000
1-1/2"	44,000	33,000

Application of the following safety factor is recommended: 4 to 1, for sizes up to ¾" O.D.; 6 to 1, for sizes ⅞" to 1 ½" O.D.



This Braze-Seal Sleeve, containing a silver alloy brazing ring, is the key to the performance of the Braze-Seal Fitting. It assures a joint that will withstand these extreme pressures because it is permanently brazed to tubing. Yet the fitting provides the convenience of a make-and-break butt joint, as illustrated, and is extremely easy to assemble.

Reducing Sleeves Provide Versatility

Can be furnished to reduce any size Braze-Seal tube end to any specified tube size. Extremely convenient on tees, for example, where any size tubing can be connected to the same tee body. Also, the same body may be used for making up flareless Hi-Seal fitting joints.

Imperial Braze-Seal Tube Fittings can be furnished in steel or stainless steel.

Check the outstanding features of Braze-Seal for yourself. Send for a sample fitting. See how Braze-Seal can help you solve the most difficult problems in super-pressure and high-temperature tube circuitry.

IT'S IN THE BOOK

Braze-Seal Fittings are covered in Imperial's new Hi-Seal Catalog — the most comprehensive coverage available on the subject of fittings, a hard-working handbook for engineers. Send for your copy today.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. PE-30, 6300 West Howard Street
Chicago 48, Illinois 8-60

units afford convenience of using single unit instead of ganged assembly. Tap permits operation at 120 v input with 280 v output for first unit; 240 v output for no-overvoltage model. **Olimite Mfg Co, 3696 Howard St, Skokie, Ill.**

Circle 323 on Reader Service Card

Hydraulic control valve . . .

has parallel internal circuit for heavy-duty mobile equipment where rapid sequence of multiple functions is required. Available in two-, three-, four- and six-plunger models, recommended for 20 gpm at 2000 psi. Valve is complete fluid-power circuit with all required or extra circuit elements incorporated. **Hydreco Div, New York Air Brake Co, 9000 E Michigan, Kalamazoo, Mich.**

Circle 324 on Reader Service Card

440-v program-time switch . . .

eliminates motor burnout by incorporating 440/120-v step-down transformer into clock. This permits use of 120-v motor. Switch allows programming of intermittent daily operations. On-off settings are in multiples of 15 min. **Tork Time Controls Inc, Mount Vernon, NY.**

Circle 325 on Reader Service Card

9-, 17-reed frequency meters

are standard in 50, 60 and 400 cps. Units can be furnished with any number of reeds from 1 to 72, any frequency from 25 to 2500 cps, with linear or nonlinear frequency spacing, from 0.4 to 10% of center frequency between adjacent reeds. Modular construction permits stocking of basic subassemblies for assembly in combinations needed. Every reed hand calibrated to within 0.3% absolute. Nominal input voltage ratings of 30, 115, 230, 480 v rms and 4½ in. rectangular and 3½ in. round meter cases are standard. **Winslow Co, 701 Lehigh Ave, Union, NJ.**

Circle 326 on Reader Service Card

Permanent-magnetic device . . .

is particularly suitable for holding or controlling parts in handling and conveying operations, or employed as separator to

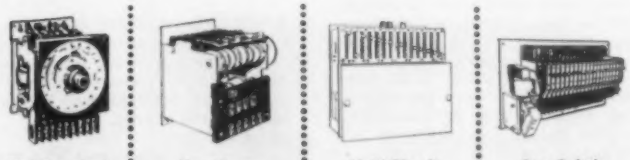
continued on page 100

with easy-to-use *EAGLE* CYCL-FLEX reset timers

A highly accurate and dependable easy-to-use timer, designed for mounting in control panels. Sealed dial protects timer when exposed to oil and dust conditions. Timer switches control four load circuits. Interlocking contacts are provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

WRITE for descriptive Bulletin 120. Address Dept. PE-360.

EAGLE HAS 24 TYPES TIME-COUNT CONTROLS



EAGLE SIGNAL COMPANY
A DIVISION OF THE GAMEWELL COMPANY
MOLINE, ILLINOIS
REPRESENTATIVES IN PRINCIPAL CITIES

CIRCLE 97 ON READER SERVICE CARD

HELPS THE HAND THAT SHAPES THE FUTURE

Castell adds drive to creative imagination

A man sits at a drawing board. The CASTELL pencil in his hand is almost an extension of the man himself—as his gray matter is translated into the gleaming black shape of a new bridge—for Africa. In other lands other creative craftsmen with CASTELL pencils conceive hydroelectric plants for India, low-cost dwellings for England, hotels for the Middle East, jet planes for the United States. CASTELL is the partner of progress the world over. Its unquestioned superiority is one of the immutable facts in a creative man's life.

#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this superb graphite into a drawing lead that lays down graphite-saturated non-feathering lines of intense opacity for cleaner, more durable originals and clearer, sharper prints. Extra strong lead takes needlepoint sharpness without breaking or splintering. Smooth, 100% grit-free consistently uniform pencil after pencil, in full range, 8B to 10H.

#9007 CASTELL Pencil with Eraser.

CASTELL Pencils and Leads draw perfectly on all surfaces, including Cronar and Mylar base films. Gives graphite-saturated lines, easy to erase, no ghosting — excellent reproduction.

***CASTELL** Rubberless MAGIC-RUB ERASER soaks up graphite without abrading drawing surfaces, and residue rolls off. Leaves no "oil" stain or "ghost." Tests highest in ease of use, line removal and non-smudging. Tests first on Cronar and Mylar base films. For all papers and vellums.*

#9800SG CASTELL LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip that lightens finger pressure without slipping, and *relieves finger fatigue.* Unique degree lead indicating device.

#9030 CASTELL Refill Lead, matching exactly #9000 pencil in quality and grading, degrees 7B to 10H, packed in reusable plastic tube with gold cap.
Many other styles and colors of CASTELL Pencils Holders and Refill Leads.

A.W.FABER-CASTELL 41-47 Dickerson Street, Newark 3, N. J.

More Performance At Less Cost:

HYDRA-DRIVES®
CDB POWER SHIFT TRANSMISSION

A torque converter...and 4-speed transmission in one compact package!

Proved in hundreds of vehicles for four years, these units assure top work output of heavy-duty equipment . . . at a lower initial cost than other models of comparable performance. Engine lugging and heavy shock loads are eliminated. A 3 to 1 torque multiplication makes starting fast and effortless – even with heaviest loads.

Simple to operate, too, a flip of the operator's lever accomplishes power shifts within each range and without any interruption of the power flow.

With four speeds forward and reverse, the CDB Hydra-Drives Power Shift Transmission is ideally suited for vehicles which must travel in both directions during a normal work cycle. Rated at 550 ft. lbs. input torque, it can be used with a wide range of internal combustion engines up to 250 H.P.

The size "C" Drop Box type transmission is illustrated above. A smaller BDB type is also available, for use with equipment of up to 175 H.P.

HYDRA DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

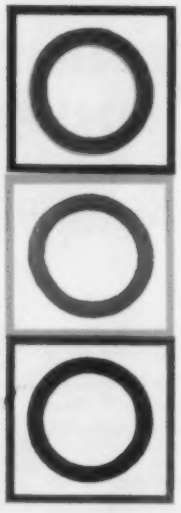
Products of **ROCKWELL-STANDARD** Corporation

CIRCLE 99 ON READER SERVICE CARD

CREATIVE ENGINEERING

is a better buy than lost time on the assembly line!

BEFORE you go into production is the time to let a Precision Sales Engineer analyze your problems, recommend solutions. As a recognized "O" Ring specialist, his knowledge and skill can help you improve product operation, simplify design, reduce assembly costs and eliminate early product failure. He'll help you obtain the right product design, then recommend the right "O" ring for the job. Precision "O" Rings are rigidly inspected, true to size and meet all military and commercial specifications.
Be safe with Precision. Write, phone, or wire for the services of a Precision Engineer today.



BE SAFE WITH PRECISION

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Dept. 6, Oakridge Drive, Dayton 7, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

100 CIRCLE 100 ON READER SERVICE CARD

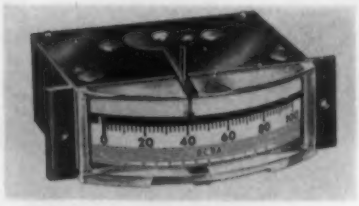
remove iron fines or small tramp iron. Powered by a Ceramic V, barium-ferric oxide magnetic material. Including steel pole plates permanently bonded to magnetic element with epoxy resin, unit is 1 x 1 in. in cross-section. Obtainable in standard widths of 4 through 72 in., in 2-in. increments. **Eriez Mfg Co, Erie, Penna.**

Circle 327 on Reader Service Card

Wound-rotor motors . . .

for adjustable or constant-speed drives that require special starting characteristics cover all standard ratings in frame sizes 254 through 326, which represents motors from 2 to 30 hp up to 1800 rpm. Wound-rotor induction motors are used wherever high starting torque, with low starting current, is required. Motors incorporate Class B insulation system. Supplied with leads for external connection for 220 or 440 v. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 328 on Reader Service Card



Miniature electronic control meter . . .

operates without electrical contacts at set points. Scale length is 2.7 in. in case that measures 3½ x 3½ x 1¾ in. Accuracy is said to be ±2% of full-scale deflection for dc. Circuit is designed for input of 22.5 v dc at 10 milliamp dc. Shield is attached to pointer of D'Arsonval-type movement, which, in turn, passes through electromagnetic field. Coils are mounted on control arm that can be set at any point on indicating scale. **International Instruments Inc, PO Box 2954, New Haven 15, Conn.**

Circle 329 on Reader Service Card

Absorption-type silencer . . .

for high-velocity air or gas flow, is leak-resistant with continuous welded shell seams, double-seal crimped ends and female pipe connections on both ends. Standard units are for air or gas service where medium is comparatively free from moisture, and temperatures up to 210 F. Available in 10 sizes from ½- to 4-in. pipe connections and up to 500 cmf capacity. **Universal Silencer Corp, Libertyville, Ill.**

Circle 330 on Reader Service Card

continued on page 104

By machining to micrometer accuracy the working surfaces within O-M Air and Hydraulic Cylinders, these units function with high operational effectiveness and a minimum of routine maintenance.

More than this, O-M precision workmanship is reflected in every engineering and construction detail. These components are designed right to seal right. The ports are readily rotated independently to a desired location. Accurate machining assures perfect piston rod alignment on extreme in and out positions, on maximum or minimum loads as well as on short or long travel.

O-M standard, oversize and 2 to 1 rods have a high yield point that increases fatigue strength. The low coefficient of friction and cushion ball-check valve provide for full-power starts. End plugs are tapped for universal mounting.

Series 101A (illustrated) and Series TH (Heavy-duty Hydraulic Cylinder) are available in a complete range of sizes (1½" to 8" bores) and a full line of mounting brackets. Immediate delivery on many sizes.

Mail coupon at once for Bulletin 101A and 105 containing engineering data on the two units.

ORTMAN-MILLER MACHINE COMPANY
15 143rd Street, Hammond, Indiana

☐ Have representative call
☐ Send Bulletins 101A and 105

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

CIRCLE 101 ON READER SERVICE CARD 101

(Advertisement)

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Why cap screws instead of studs?

Many types of products once fastened with studs are today assembled with cap screws. Why the change in preference?

Studs show certain advantages in large diameters and in high temperature applications. But when it comes to smaller sizes used in tapped holes, designers and production people have found more advantages in cap screws.

ASSEMBLY FACTORS

In fastener selection for a given application, you have to consider production and assembly as well as joint strength.

Obviously, studs require two wrenchings (first stud, then nut). Also, there's a more expensive close tolerance tapping job, since a stud takes an interference fit to stay tight and not withdraw when nut is backed off.

Cap screws require only a clearance fit. Used in a tapped casting, they can be repeatedly inserted and unscrewed without damage to threads.

HOW NOT TO USE STUDS

Studs are not meant to serve as dowels to locate and line up for fastening. To line up numerous studs and bring two pieces together raises assembly cost. Use dowel pins for alignment and use cap screws for fastening to achieve greater economy.

Screw develops high thread tension . . . and stays locked in place

RB&W TENSILOCK screw, despite the friction of the toothed flange, develops 4000 pounds tension with on-torque of 240 inch-pounds.

An off-torque of 330 inch-pounds fails to break loose the grip of the teeth. Tension is maintained by TENSILOCK screw.

Here is a locking fastener where the on-torque effort not only *anchors* the screw but also develops high preloading, or residual tension.

Like high tensile cap screws, RB&W's TENSILOCK* screws also give a high thread tension to torque ratio. But there's one important difference. The TENSILOCK fasteners lock with *teeth* as well as high residual tension.

RATCHET-LIKE LOCKING

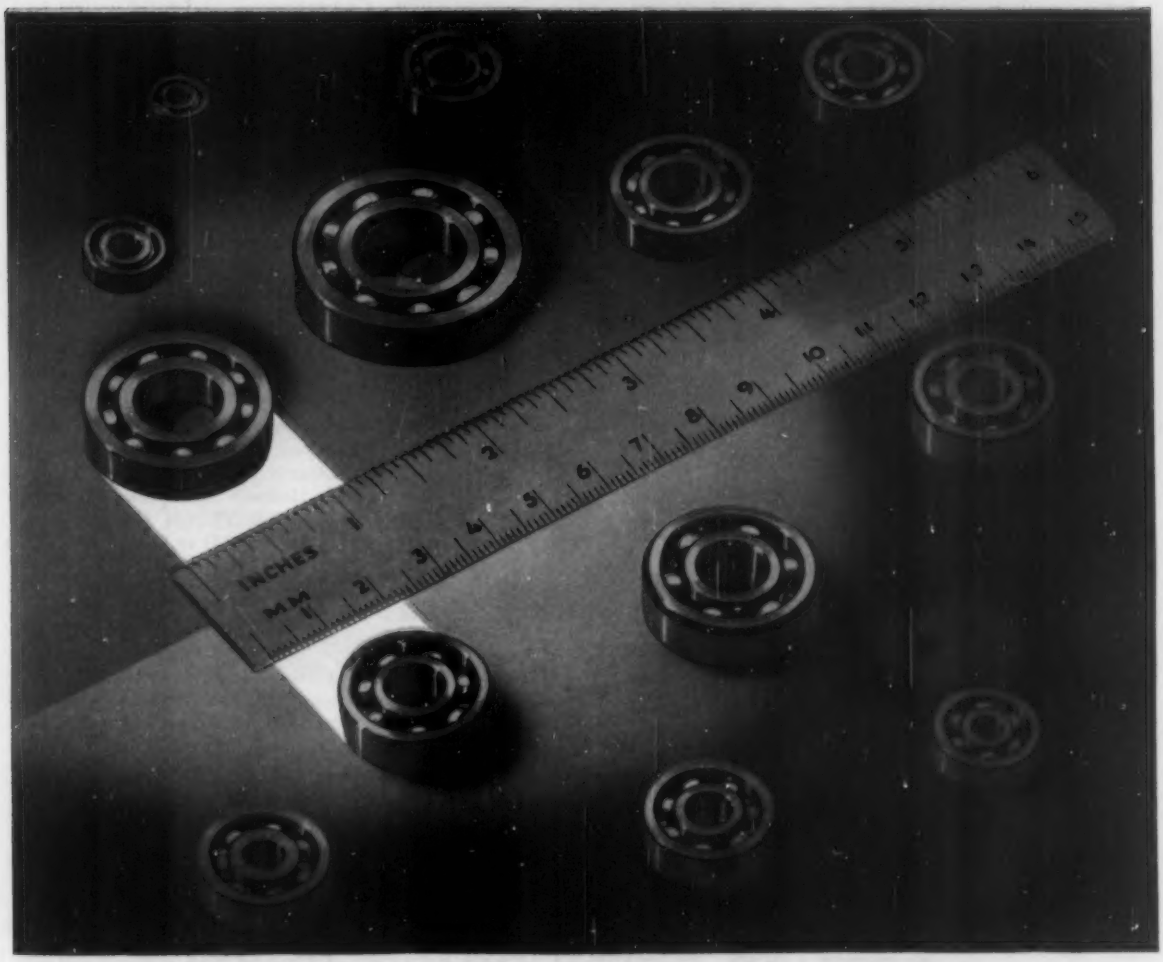
Carburized teeth on flange of this one-piece fastener are so angled as to afford easy torquing. They bite into the seating surface when fastener is fully tightened. A circular groove in the flange increases flexing action and enables flange to maintain pressure on the imbedded teeth. To *loosen* a tightened TENSILOCK fastener thus takes much more effort than the on-torque. And it can be reused with little loss of this holding power.

FRICTION STOPS SLIPPAGE

The full clamping force exerted by these fasteners prevents slippage of the fastened members where lateral movement is possible because of large or eccentric holes. The positive gripping enables them to stay tight even under conditions of severe vibration or cyclic temperature fluctuations. RB&W TENSILOCK nuts also available. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*Trademark Pat. applied for

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



NOW! *hoover quality* BALL BEARINGS IN INCH AND METRIC DIMENSIONS

Hoover Quality is featured in two new Hoover deep-groove bearing series. Now available in a complete range of sizes and modifications are R series bearings in inch dimensions, and extra small 30 series bearings in metric dimensions.

R SERIES are proportionately similar to conventional extra light and light series bearings except that bore, outside diameter and width are made to fractional inch dimensions. R series bearings are available in open, single shield or double shield types . . . bore sizes ⅛ to 1½ inch.

30 SERIES are designed for applications requiring bearings smaller than conventional extra light and light series ball bearings. Open, and single or double shielded or sealed types are available. Bore sizes range from 4 to 9 mm.

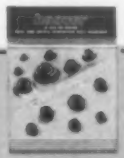
Return the coupon below for complete information.

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Zone Sales Offices and Warehouses	8581 South Chicago, Chicago 17, Illinois 290 Lodi Street, Hackensack, New Jersey 2020 South Figueroa, Los Angeles 7, California



PE-3

Hoover Ball and Bearing Company
5400 South State Road, Ann Arbor, Michigan

☐ Please send Bulletin 112 which describes R and 30 series ball bearings

☐ Have your representative call.

Name_____

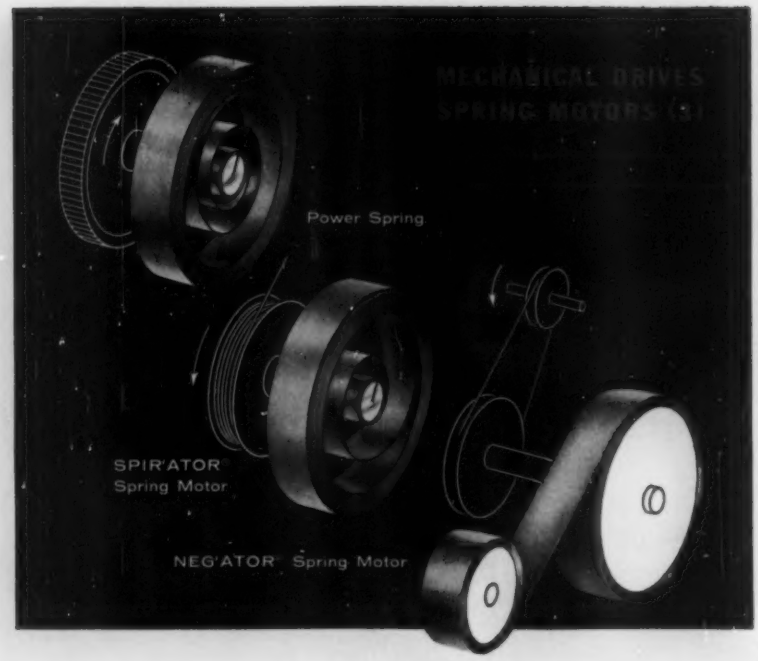
Title_____

Company_____

Address_____

City_____ Zone_____ State_____

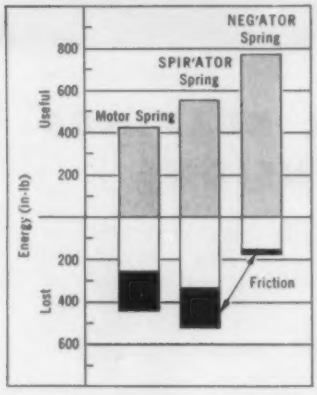
CIRCLE 103 ON READER SERVICE CARD 103



Drive it with

HUNTER SPRING POWER

Energy comparison of three Hunter motor springs having same weight of material



HUNTER POWER SPRINGS

These familiar, inexpensive springs are better than ever before. Using materials and techniques discovered in manufacturing constant-force springs, Hunter has bettered the performance of, and added life to, conventional power springs.

HUNTER SPIR'ATOR® MOTORS

These prestressed spiral springs by Hunter are related to the power spring and the NEG'ATOR spring. They *look* like power springs—are *made* like NEG'ATOR springs. SPIR'ATOR motors produce as much as twice the length of running cycle in the same size package as a power spring.

HUNTER NEG'ATOR® MOTORS

These unusually long-running motors release the maximum useful energy and provide constant torque output. In NEG'ATOR motors, design engineers have a unique mechanical drive unit that provides many more turns than any other, is compact, very powerful and will not jump or skip.

For a detailed comparison of these three drive units, write for a copy of "Motor Springs" to the address below.

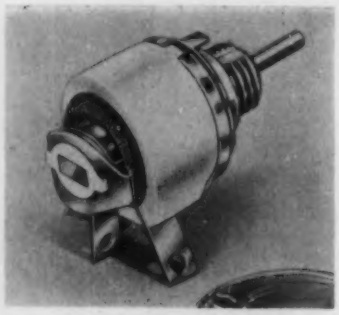
HUNTER

HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

5 Spring Avenue, Lansdale, Pennsylvania

SPRINGS · STAMPINGS · QUALITY CONTROL EQUIPMENT



Subminiature 5-w rheostat . . . has diameter of 0.5 in. Operating temperature is 580 F, with built-in safety factor. Hardwick Hindle Inc, 40 Hermon St, Newark 5, NJ.

Circle 331 on Reader Service Card

Dual 4-port selector valve . . . is actuated by 90° rotation of single handle. Permits reversal of flow direction of two fluid systems through two alternate systems. Intended for use with precision test systems requiring simultaneous, dual-system control. Available in aluminum or 303 stainless steel. Operates at —40 to 350 F, depending upon O-rings specified. Connections are ¼ in. NPT. Dual valve may be used with pneumatic or gas-handling apparatus. Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena, Calif.

Circle 332 on Reader Service Card

Filled-Teflon piston rings . . . are suitable for nonlubricated service to seal reciprocating, oscillating and rotary motion of both external and internal cylindrical surfaces against leakage of liquids or gases. Made from carbon-filled Teflon. For continuous service in temperatures of —420 to 500 F. Available in many different designs, including butt joint, step joint, scraf cut or solid. Garlock Packing Co, 444 Main St, Palmyra, NY.

Circle 333 on Reader Service Card

Sealed precision switch . . . weighs less than 1/28 oz. Envelope measures 0.320 in. dia x 0.440 in. long. Hermetically sealed and filled with dry, inert gas. Current capacity is 3 amp, 28 v dc, resistive. Ambient temperature range is —65 to 275 F. Contact arrangement is SPDT. Resists 40 g vibration and 100 g shock. Has overtravel of 0.003 in. min. Actuating force is 12 oz ±8 oz; release force, 1 oz min. Spencer Products Group, Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.

Circle 334 on Reader Service Card

continued on page 106

When rubber parts must deliver...

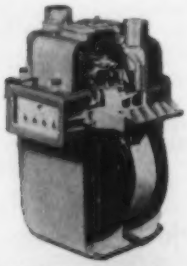
HIGH RESISTANCE TO SOLVENTS

LOW TEMPERATURE FLEXIBILITY

SUPER IMPERMEABILITY TO GASES

LONG, LIVELY LIFE

THIOKOL POLYSULFIDE CRUDES are PICKED FOR THE BIG JOB



REEVES BROTHERS, INC. USES THIOKOL polysulfide rubber in production of Reeves-Vulcan gas meter diaphragms. Its resistance to oils, organic solvents and impermeability to gases assure accurate metering.

High resistance to organic solvents, dilute acids, alkalies, and aromatic fuel. Impermeability to gases, moisture, liquids. Low temperature serviceability—to -60°F without plasticizers. Resistance to ozone, sunlight, weathering over long periods of time, without serious loss of serviceable properties.

Good reasons why THIOKOL polysulfide crudes are widely used in printing and coating rollers, solvent, paint and fuel hose, diaphragms and gaskets. Perhaps they hold the answer to improved product processing for you. Want the facts and technical assistance? Write to THIOKOL at address below.

Thiokol CHEMICAL CORPORATION

780 N. Clinton Avenue, Trenton 7, New Jersey

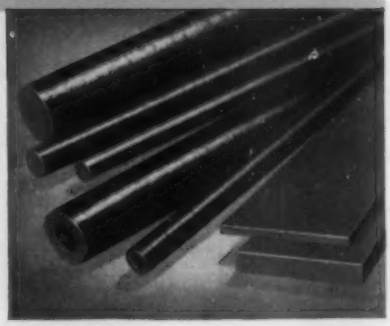
In Canada: Naugatuck Chemicals Division, Dominion Rubber Company, Elmira, Ontario

® Registered trade mark of the Thiokol Chemical Corporation for its rocket propellants, liquid polymers, synthetic rubber, plasticizers and other chemical products.

Chemically Inert Dry Bearing Material

Chemloy 719*

use without lubricant!



Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

*The best in Teflon based bearing materials.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p specs. for quotation on molded or machined parts. Crane Packing Company, 6445 Oakton St., Morton Grove, Ill. *(Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ontario.*

Teflon is a DuPont Trademark

John Crane

CRANE PACKING COMPANY

Nylon-reinforced PVC hose . . . withstands up to 1500 psi, yet retains qualities of standard plastic hose. Nylon braiding enclosed within wall is protected from abrasion and penetration of oil or dirt. Working temperature ranges from 170 to −5 F. Burst pressure of ⅛-in.-ID hose is 1500 psi; of ¼-in.-ID hose, 1200 psi; of ½-in.-ID hose, 800 psi. Standard sizes range from ⅛ to 1¼ in. ID. **Newage Industries, 222 York Rd, Jenkintown, Penna.**

Circle 335 on Reader Service Card

⅝-in.-dia potentiometers . . . have resistance range of 250 ohm through 2.5 megohm linear taper; wattage rating is ¼ w through 100,000 ohm and ⅛ w over 100,000 ohm at 131 F derated to no-load at 185 F. Voltage rating is 750 v ac, bushing to terminals, for 1-min. high-spot test; 500 v dc operating max; 350 v dc across end terminals. Base prices in 3000 to 9999 quantities start at $160.42 per 1000 without switch; $316.93 per 1000 with switch. Delivery is 4 to 5 wk after sample approval. **Chicago Telephone Supply Corp, Elkhart, Ind.**

Circle 336 on Reader Service Card

Adjusting drafting table . . . has flat drawing surface that adjusts from desk height of 29 in. to drafting table height of 38 in. Height and top-tilt adjustments are made from front of table and are counterbalanced. Top tilts from horizontal to 90° vertical. Table tops are available in 37½ x 54- and 37½ x 60-in. sizes. Tops are made of solid basswood with steel edges. **Mayline Co Inc, Sheboygan, Wis.**

Circle 337 on Reader Service Card

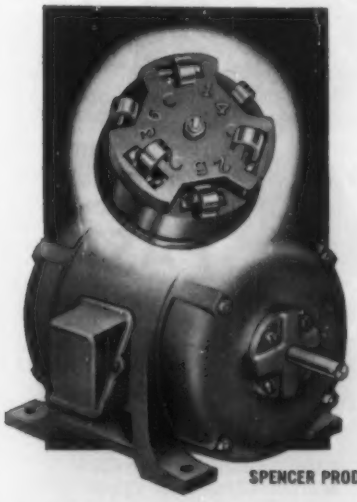
Plastic planking . . . to replace mahogany and other materials as a pattern and model-making material, is said to eliminate unnecessary waste because of warpage, grain and knots. Supplied in standard lumber sizes of 1 x 6 ft and thicknesses of 2 and 2½ in. Density of plastic planks is comparable to that of mahogany, about 36 to 44 lb per cu ft. It may be carved, sawed, chiseled, planed or shaped with conventional woodworking tools. **Ren Plastics Inc, 5422 S Cedar Rd, Lansing 9, Mich.**

Circle 338 on Reader Service Card

HUNTING

for a Solution to STOP MOTOR BURNOUTS

Specify and use 3-phase motors with built-in KLIXON PROTECTORS



SPENCER PRODUCTS

RESULT . . . • *Eliminate Motor Burnouts* • *Get Maximum Motor Output* • *Reduce Costly Equipment Down Time*

No matter what the motor application . . . whether it be textile looms or turret lathes . . . ventilating fans or rolling mills . . . built-in KLIXON Protectors keep motors from burning out under all conditions that cause overheating.

Built-in by the motor manufacturer, as an inherent part, KLIXON Protectors are matched to the thermal characteristics of the motor providing a tested and proven combination to assure full protection. KLIXON Protectors safeguard motors and prevent burnouts caused by the following conditions . . . prolonged overloads, unbalanced voltage, stalling, failure to start, increased ambient temperatures, lack of ventilation, plugging,or reversing duty, and single phasing.

And remember, get the same complete protection in your single phase motors, too.

KLIXON protected motors are available from your motor supplier. The additional cost is low, the savings great. Ask your motor supplier for KLIXON protected motors.

Write for a free copy of Bulletin PR-1243. It gives the complete story.

TEXAS INSTRUMENTS
INCORPORATED
METALS & CONTROLS DIVISION
3803 FOREST STREET • ATTLEBORO, MASS.

SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

FOR CUSTOM COMPOUNDED PRECISION FABRICATED

Go Goshen RUBBER PARTS SEALS PRODUCTS

O-RINGS

TO MEET ADVANCED REQUIREMENTS

Capitalize on Goshen's experience in serving the needs of hundreds of large and small users of o-rings in the United States and Canada. Precise control of quality thru every stage of formulation and manufacture is the key to an outstanding record of sealing success.

GRC o-rings in all standard AN, MS, SAE and JIC sizes, in many non-standard sizes and in special sizes, are available from established and proven synthetic and silicone specification compounds. Go Goshen for efficient sealing under most any given conditions.

Ask for your free copy of 16-page O-ring Brochure on size, groove dimensions, compounds and other helpful information.

Goshen Rubber Co., INC.

2030 S. TENTH STREET, GOSHEN, INDIANA

108 CIRCLE 108 ON READER SERVICE CARD

ALLIED DIVERSE TYPES OF

DRIVE WHEELS

SIMPLIFY YOUR PRODUCT PROPELLING PROBLEMS!

ALL TYPES—MANY SIZES:

● Let field tested and proven ALLIED Drive Wheels solve your propelling requirements. Big selection of high production stock types and sizes, at favorable prices!

SPROCKET DRIVE WHEELS — 7 to 10" dia. for low speeds and weights.

PULLEY DRIVE WHEELS — 8 to 12" dia. for up to 350 lb. loads.

KEY DRIVE WHEELS — 8 to 12" dia. for 10 mph speed and larger loads.

WASHER DRIVE WHEELS — 6 to 12" dia. for walking speed only.

COTTER PIN DRIVE WHEELS — many sizes.

VARIATIONS AT SMALL COST

Slight modifications of ALLIED stock Drive Wheels can be made with minimum or no tooling cost—to meet O.E.M. precise requirements in production quantities!

FREE ROLLING WHEELS TO MATCH

ALLIED offers matching companion wheels for all types and sizes of Drive Wheels—with choice of any standard wheel bearings. Hub Caps available for all wheels too!

FOR DETAILS, WRITE DEPT. PE

ALLIED WHEEL PRODUCTS, Inc.

27 BROADWAY • TOLEDO 4, OHIO

Representatives and Warehouses in Fifty Principal Cities

CIRCLE 205 ON READER SERVIEC CARD

NEW!

SPRING & FUSE CLIPS, LOCK WASHER TERMINALS

Order from Zierick stocks for quick delivery. New terminals with #4, 6, 8 holes, spring and fuse clips made from .018 brass or phosphor bronze, hot tinned. Special parts quoted from sketches or blueprints. Production on our upright presses or multi-slide machines. Over 500 stampings and wire forms to choose from.

STANDARD ELECTRICAL PARTS delivered FAST!

Lugs • Clips • Terminals
Wire Forms from Stock

Send for your copy of the new Zierick catalog No. 22 TODAY!

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112 Beechwood Ave., New Rochelle, N. Y. • NEw Rochelle 6-8520

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DESIGN LITERATURE

Manual of Mathematical Physics

PAUL I RICHARDS. Pergamon Press Inc, 122 E 55th St, New York 22. 7 x 10, 486 pp. $17.50.

Here is a concise source of information on theoretical physics and allied mathematical techniques. It contains a wide selection of formulas and statements which are either basic to physical theory or useful in a wide range of applications. The physics section has been confined to well-established theories and the mathematical section omits material already available in handbook form. Each term and concept above the level of elementary calculus is somewhere defined.

This book is a dictionary of terms and concepts, with continuity maintained by a series of comments and derivations. Level of treatment varies with the level of the material; but it is always highly condensed and must therefore be considered advanced, despite the inclusion of much elementary and fundamental material.

Nuclear Power Plant

E OPENSHAW TAYLOR. Philosophical Library Inc, 15 E 40th St, New York. 5½ x 9, 184 pp. $7.50.

For the engineer who wants to know, in simple, brief outline, what neutrons are, how neutron flux is measured, and what is the difference between a pressurized-water and a boiling-water reactor, the first four chapters of this book are an excellent reference. The remainder of the volume, more detailed and more technical, discusses coolants, control and instrumentation and economics. It is directed more specifically to those associated with the nuclear energy field. The writing is, however, quite clear and simple even in this section.

US and Foreign Specs for Steel Castings

British Steel Castings Research Assoc, East Bank Rd, Sheffield 2, England. Part I; 11 x 9, 48 pp. $7.50.

Various European and US specifications for steel castings are summarized and compared with British standards. This booklet presents detailed comparison of specs from Austria, Belgium, France, East and West Germany, Sweden, Switzerland, US. (US specifications covered are ACI, ASTM, SAE, and AMS).

It also lists, for reference, equivalent standards from Czechoslovakia, Holland and Italy. Although treatment is limited to steel castings, it should prove to be extremely useful for those who deal with foreign countries.

Value Engineering

Proceedings of the 1959 EIA Conference on Value Engineering. Interscience Publishers Inc, 250 Fifth Ave, New York 1. 6 x 9, 165 pp. $6.

Value engineering, or value analysis as it is frequently called, is a new engineering specialty paying large dividends to both supplier and customer. This book contains the complete versions of all of the technical papers presented at the first comprehensive conference on value Engineering held at the U of Pennsylvania, Oct 6 and 7, 1959. The 17 papers cover basic concepts and philosophy, technique, application, and relationship with other work areas.

Contributors are from such organizations as General Electric, Stromberg-Carlson, Raytheon, Bureau of Ships and Bureau of Aeronautics of the Navy Dept, Army Rocket and Guided Missile Agency, and Watervliet Arsenal.

Engineering Manufacturing Methods

GILBERT S SCHALLER. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 7 x 10, 682 pp. $9.50.

This book assembles, in one place, up-to-date information on most production processes. It covers metalworking quite broadly—casting an ingot or part, working and cutting it, and assembling by welding and brazing. Unfortunately, it includes relatively little information of direct value for design.

Spacing of On-off Control—II: Toggle Switches

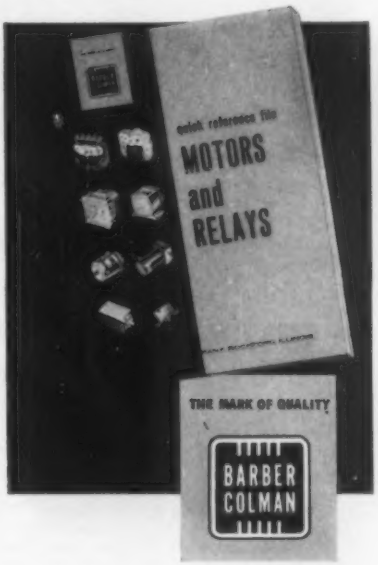
J V BRADLEY, R A WALLIS. Dept of Commerce, Office of Technical Services, Washington 25, D.C. 8½ x 11, 21 pp. 75¢.

Here are the results of a test (published by Wright Air Development

continued on page 110

NEW, FREE

quick reference file...a-c and d-c small motors, tach generators, relays...



Get this helpful quick reference file that illustrates and gives typical specifications for the wide selection of Barber-Colman small motors (to 1/10 hp), relays and related components for electronic applications. Here you'll find many practical solutions to complex control problems . . .

A-C SHADED-POLE MOTORS
unidirectional • reversible
synchronous • geared

A-C and D-C TACH GENERATORS

D-C PRECISION MOTORS

BATTERY-OPERATED MOTORS

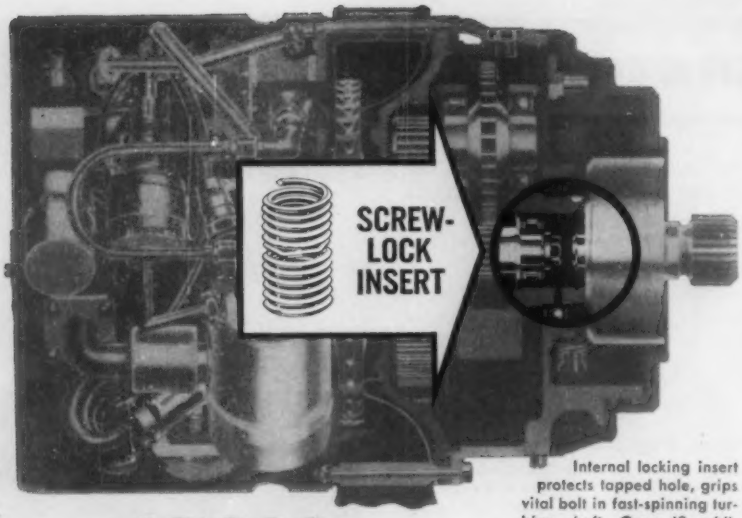
A-C 400-CYCLE MOTORS

BLOWERS, GEARHEADS

ULTRA-SENSITIVE RELAYS

Send for your copy Quick Reference File F-9765.

BARBER-COLMAN COMPANY
Dept. C, 1212 Rock Street
Rockford, Illinois



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

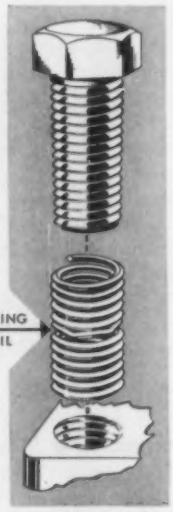
at 46,000 R.P.M.

HELI-COIL®

SCREW-LOCK INSERT*
holds this vital bolt fast
...Without Lock Washers
or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking Heli-Coil* Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these *Heli-Coil* stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of *Heli-Coil* Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

***Heli-Coil* Screw-Lock Inserts**

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 603 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts
NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____ PE 1772

In Canada: Armstrong Beverley Engineering Ltd., 6975 Jeanne Mance Street, Montreal 15, Que.

Center) in which 36 subjects were asked to operate a toggle switch placed between two other toggle switches. The number of times adjacent switches were inadvertantly operated or touched was recorded. The tests were repeated with different switches and different spacing between switches. Results showed that when switches are less than 1 in. apart, best performance is obtained with miniature toggle switches having considerable switching resistance.

Other Books of Interest

A History of Mechanical Inventions
Abbott Payson Usher. Beacon Press, 25 Beacon St, Boston 8. 5¼ x 8, 450 pp. $2.25.
This is a new paperback edition of an excellent classic text on this subject.

Systems and Procedures Responsibility
Philip H Thurston. Harvard Business School, Div of Research, Soldiers Field, Boston 63. 5¼ x 8, 110 pp. $2.50.
Presents an administrative view of the division of responsibility between operating people and specialists for systems and procedures work.

Trial American Standard Class 5 Interference-fit Threads, Bl.12
ASME, 29 W 39th St, New York 18. 8½ x 11, 12 pp. $1.

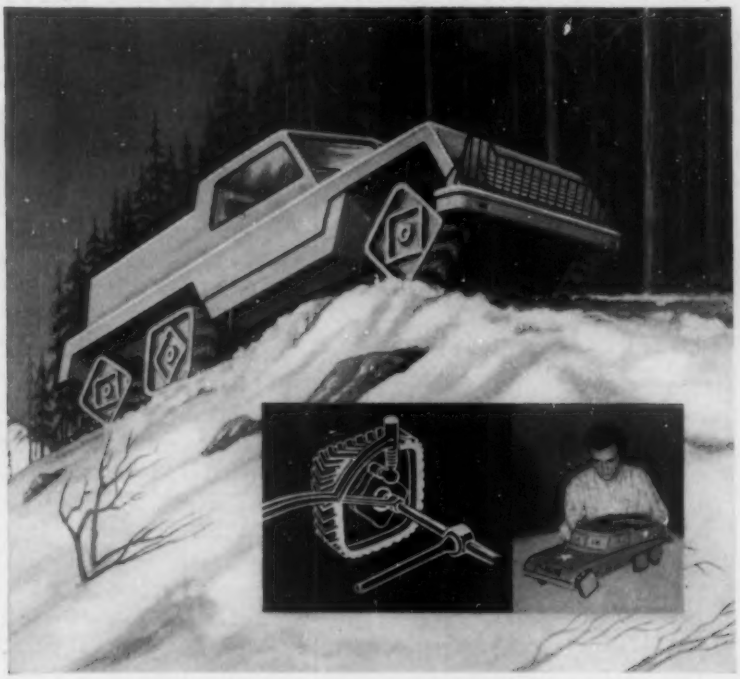
Industrial Laminated Thermosetting Products
LP1-1959. National Electrical Manufacturers Assn, 155 E 44th St, New York 17. 8½ x 11, 70 pp. $2.75.

Efficiency of a Thermomagnetic Generator
151736. H E Stauss. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 7 pp. 50¢.

continued on page 112

"Hello Ed? Charlie. Say, Ed, I've got a problem: Must we adhere to the college degree line or can we take into account practical experience?"

No. 14 • Mars Outstanding Design Series

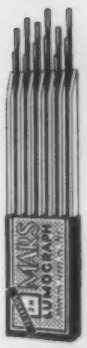


SQUARE WHEELS? Yes ... square wheels. Operating by means of a floating axle and cam gear, they take the bumps out of rough terrain and provide more traction. U.S. Patent No. 2786540 has been granted to designer Albert Sfredda of Bethlehem, Pa., for his invention.

The square shape gives superior traction in mud, sand, snow or uneven terrain. The flat surfaces of the wheels bridge the ruts instead of sinking into them as do round wheels. The wheels can be in any relative position, do not need to be synchronized—yet they run smoothly. Designed for use on heavy trucks, jeeps, farm or construction machinery, speeds up to 35 miles per hour can be attained.

This ingenious departure from age-old precedent is just one example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.



Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

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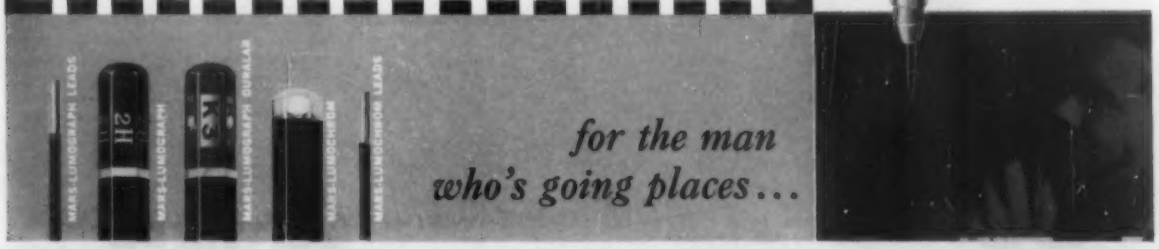

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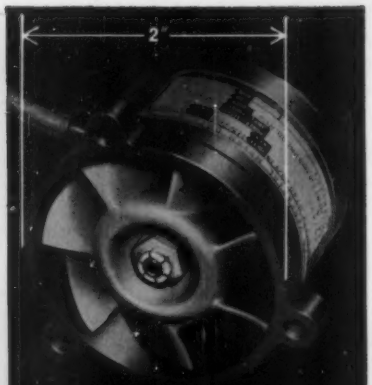

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AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H_2O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- Volume flow: 21.5 to 53.5 cfm
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- Speed: 10,500 to 22,500 rpm
- Single, two or three phase power
- Power: 16 to 69 watts
- Standard or high slip motors
- Weight: .36 to .48 lb.

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

1960 SAE Handbook
Society of Automotive Engineers Inc, 485 Lexington Ave, New York 17. 8¾ x 11, 903 pp. $20.

American Standard Rotating Air Cylinders and Adapters
B5.5-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 6 pp. $1.

ABSTRACTS FROM THE LITERATURE

Metal-finishing Techniques

Advantages and disadvantages of the various types of polishing, plating, and painting processes are discussed. Includes a page of sketches giving "good" and "bad" design details, according to the limitations of the techniques involved. Preparation of specifications is also briefly described.

"Designing for Simpler Metal Finishing Techniques," Adrian Walmsley, Chairman, N Branch, Institute of Metal Finishing (United Kingdom). Engineering Materials and Design, Jan '60, Drury House, Russell St, London W C 2, England.

Low-friction Sliding

A very low friction, about 10^{-2}, has been unexpectedly observed in reciprocating sliding of gold, silver, copper, and platinum. It was found that characteristics common to those metals were soft metal substrate and no surface oxide or soft oxide.

"Low Friction of Metals in Reciprocating Sliding," Yasukatsu Tamai, Aeronautical Research Institute, Meguro, Tokyo, Japan. Journal of Applied Physics, Dec '59, 335 E 45th St, New York 17.

Engineering Management

Discusses the peripheral problems, responsibilities and techniques that the manager of engineering must un-

continued on page 114

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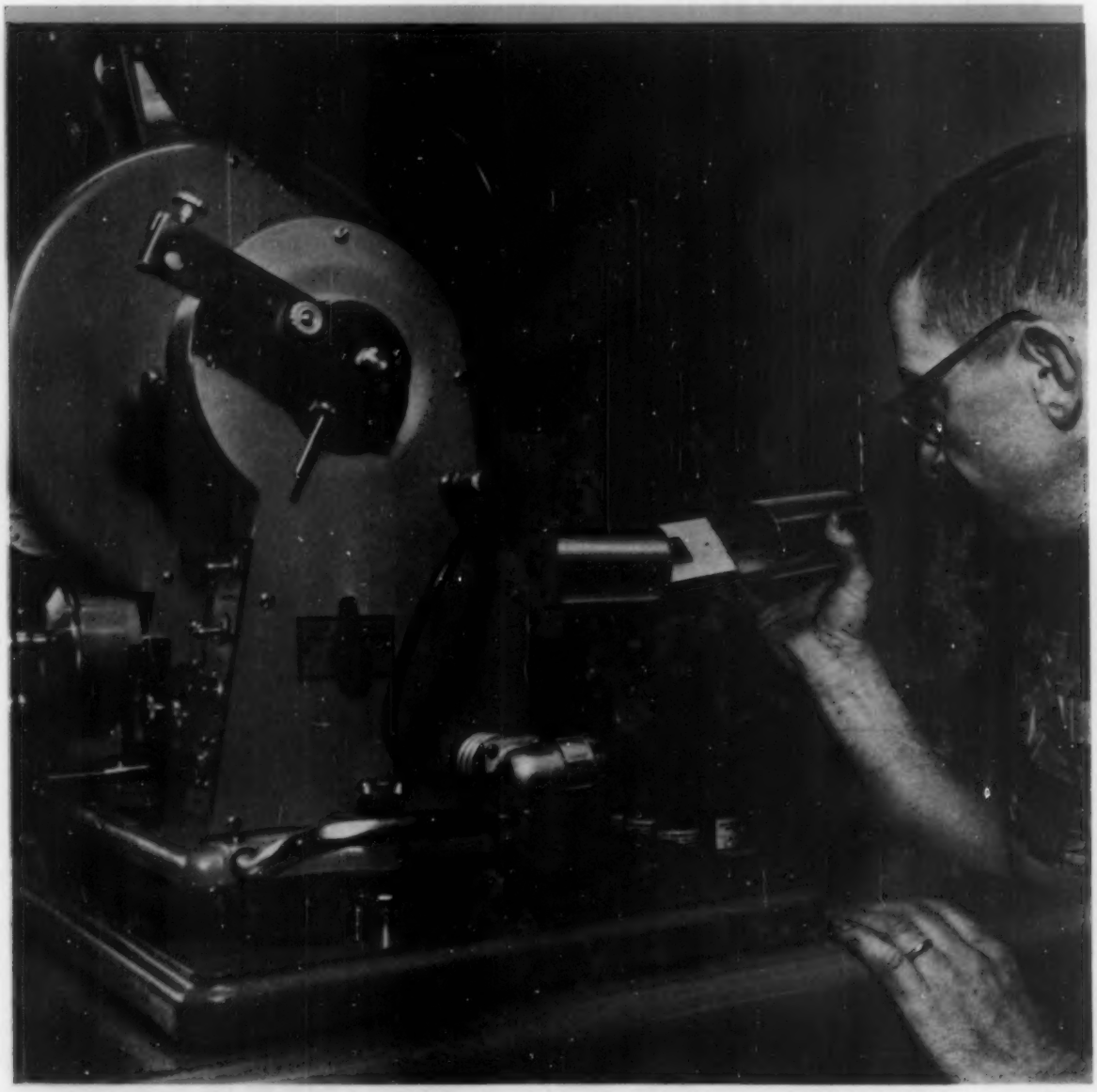

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derstand, beyond the knowledge and training immediately associated with technological work programs. Among the fields which may touch upon the engineering administrator's work are: sociology, public administration, political science, psychology, law, economics, accounting, physiology and biology. A listing of specific work functions and their relationship to the management of engineers is included.

"Peripheral Professional Problems of Engineering Management," C. F. Savage, General Electric Co. Electrical Engineering, Dec '59, 33 West 39th St, New York 18.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 119.

FASTENER FATIGUE—Manual 5930, 32 pp. Illustrates thread form which is said to double fatigue endurance of standard high-tensile bolt. Includes 17 pp on causes of fastener fatigue, drawings of nuts incorporating new thread form, and applicable fatigue-performance test results. Elastic Stop Nut Corp of America, Dept D/D, 2330 Vauxhall Rd, Union, NJ.

Circle 350 on Reader Service Card

PLASTICS PROPERTIES—Calculator. Designates proper plastic when property is known or desired property when plastic is known. Also lists properties of injection- and blow-molding resins and styrene molding compounds. Monsanto Chemical Co, Springfield 2, Mass.

Circle 351 on Reader Service Card

FABRICATING AND WELDING TITANIUM—Booklet 3, 24 pp. Contains information on approved methods for fabricating and welding titanium and titanium alloys. Republic Steel, 1441 Republic Bldg, Cleveland 1.

Circle 352 on Reader Service Card

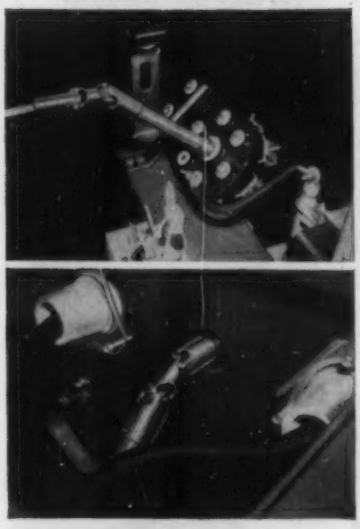
AIR AND HYDRAULIC CYLINDERS—Bulletin P25447P, 24 pp. Covers air and hydraulic cylinders, accumulators, hydraulically controlled air-power units, boosters and pipe-thread fittings. Includes mounting and dimensional information and thrust charts. Lists various services rendered. Flick-Reedy Corp, York and Thorndale Rds, Bensenville, Ill.

Circle 353 on Reader Service Card

CENTRALIZED LUBRICATION SYSTEMS—Bulletin 26-T, 24 pp. Discusses advantages of centralized lubrication and

continued on page 115

CURTIS HELPS THIS SWITCH LIVE TO A RIPE OLD AGE



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principles of operation, as well as system components. Contains illustrations of typical applications. Farval Div, Eaton Mfg Co, 3300 E 80th St, Cleveland 4.

Circle 354 on Reader Service Card

LOCK, WELD AND SEMIFINISHED NUTS—Catalog, 8 pp. Lists entire line of nuts, with sizes and specifications. Contains application information. Includes abbreviated version of Industrial Fasteners Institute test procedure for prevailing torque-lock nuts. MacLean-Fogg Lock Nut Co, 5535 N Wolcott Ave, Chicago 40.

Circle 355 on Reader Service Card

O-RINGS—Brochure, 8 pp. Describes line of O-rings for all phases of industry. Tables indicate sizes, dimensions, cross-sections, diameters, seal materials. Covers military specifications; resistance to heat, cold, chemicals and other environmental factors. Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Calif.

Circle 356 on Reader Service Card

TRANSFORMERS—Catalog S-105, 36 pp. Lists over 750 transformers with electrical and physical specifications. Chicago Standard Transformer Corp, 3501 Addison St., Chicago 18.

Circle 357 on Reader Service Card

BLIND RIVETS—Catalog, 8 pp. Discusses how rivets operate, two basic types, selecting proper rivet; explains method for ordering; lists tools available for installation. Pop Rivet Div, United Shoe Machinery Corp, Shelton, Conn.

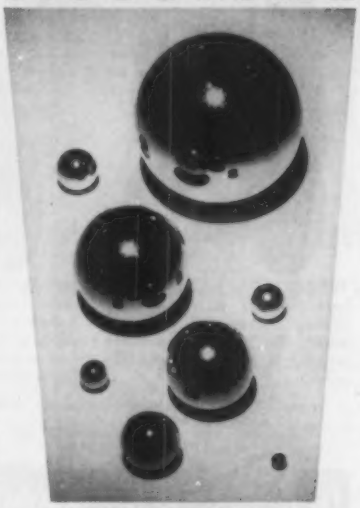
Circle 358 on Reader Service Card

VALVES—Booklet 5911251, 8 pp. Presents valves for fluid-flow and condition control, with design information, charac-

continued on page 117

"That's one way to do it . . . Now, why don't we draw it to the opposite hand and see how it looks that way?"

HARD SMOOTH AND ACCURATE



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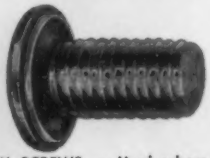
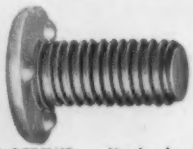
HH SCREWS — Used where a single, button-type projection is required when welding to curved surfaces, to heavy sheet 3/32" or thicker, or to ends of rods.



RW SCREWS — Used where a hermetic seal is required to prevent leakage of air, gas, water, oil or dust, or when welding to perforated metal or wires.



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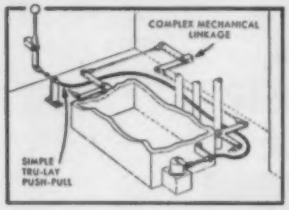

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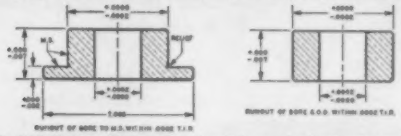

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teristics, range specifications and illustrations. Office of Technical Publications, United Aircraft Products Inc, 1116 Bolander Ave, Dayton 8, Ohio.

Circle 359 on Reader Service Card

ROTARY SOLENOIDS, SELECTORS, STEPPING MOTORS–Bulletin A-1259, 8 pp. Contains physical, performance and environmental information on more than 250 models and tells how to use these data to select proper rotary solenoid, selector or stepping motor. G H Leland Inc, 123 Webster St, Dayton 2, Ohio.

Circle 360 on Reader Service Card

OPTICAL FACILITIES FOR INDUSTRY–Brochure, 16 pp. Outlines and illustrates optical facilities for photography, science and industry. Appendix contains glossary of terms most used in optics. Tiffen Optical Co, 71 Jane St, Roslyn Heights, NY.

Circle 361 on Reader Service Card

RWMA FACILITIES–Promotional leaflet, 8 pp. Tells of services offered to industry by Resistance Welder Manufacturers Assn; describes education aids available and includes up-to-date lists of association publications. Resistance Welder Manufacturers Assn, 1900 Arch St, Philadelphia 3.

Circle 362 on Reader Service Card

NON-DRIFT ROTARY SWITCH – Folder, 4 pp. Describes and illustrates type 212 rotary switch. Includes dimensional drawings and page of standard stock assembly layouts. Trolex Corp, McHenry, Ill.

Circle 363 on Reader Service Card

DESIGN IDEAS–Technical publication, Vol. 1, No. 1. Quarterly devoted to instruments, techniques and applications in

continued on page 119

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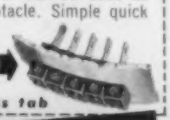
ACCORDIAN TYPE
Fit curved surfaces
Nylon bushing – brass tab



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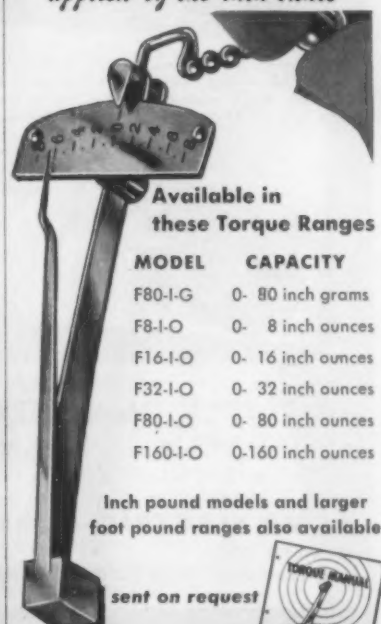

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F8-I-O	0- 8 inch ounces
F16-I-O	0- 16 inch ounces
F32-I-O	0- 32 inch ounces
F80-I-O	0- 80 inch ounces
F160-I-O	0-160 inch ounces

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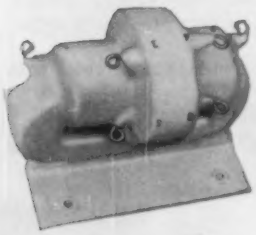
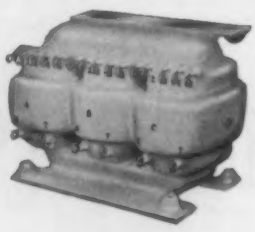
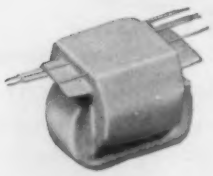


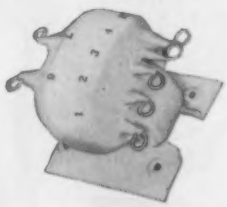
T-36127
Weight: 14 ounces. VA: 47.8
50°C rise, 125°C ambient
12 KV test @ 30,000 feet



T-34671
Weight: 4¼ lbs. VA: 705
165°C rise, 125°C ambient
12 KV test @ 30,000 feet



T-34894
Weight: 260 grams VA: 26.4
30°C rise, 125°C ambient
6.2 KV test @ 30,000 feet



T-36196
Weight: 235 grams. VA: 32
31°C rise, 125°C ambient
5.2 KV test @ 30,000 feet

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TRANSFORMERS

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COHRlastic C-319 RTV (room temperature vulcanizing) cement may be used for bonding silicone rubber or silicone sponge to itself, and for bonding silicone gaskets and seals to metal, the latter with the aid of C-320 metal primer. C-319 also makes a convenient patch system for silicone rubber seals. High temperature limit is 350°F.
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COHRlastic C-328 RTV is an exclusive room temperature vulcanizing fluoro-elastomer cement for bonding Viton. It is resistant to fuels and chemicals and temperatures up to 500°F. Potential uses include lining tanks to prevent corrosion; potting and sealing, where fuel and chemical resistance is required. Temperature range –50°F to 500°F.
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electronics measurements field. Electro Scientific Industries Inc, 7524 S W Macadam Ave, Portland 19, Ore.

Circle 364 on Reader Service Card

NAMEPLATES—Bulletin 900, 4 pp. Specifications and prices of nameplates and identification products. Seton Name Plate Co Inc, 431 W Rock Ave, New Haven 15, Conn.

Circle 365 on Reader Service Card

HI-TEMP LAMINATES—Bulletins, 1 pp each. Describes properties and characteristics of grades ARF-HT and G3-HT, both high-temperature, phenolic laminated plastics. Synthane Corp, Oaks, Penna.

Circle 366 on Reader Service Card

DIGITAL LOGIC CIRCUIT PLUG-IN MODULES—Bulletin 59-B, 4 pp. Block diagrams, descriptions, specifications and suggested applications are shown for each of eight plug-in models. Rese Engineering Inc, 731 Arch St, Philadelphia 6.

Circle 367 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

ZIRCONIUM—Fact file-folder. Contains information on zirconium and zirconium alloys, their applications and available forms, as developed and compiled by zirconium producers and fabricators. Zirconium Association, 2130 Keith Bldg, Cleveland 15.

MINIATURE BEARINGS—Design and purchasing manual, 140 pp. Specifications on 370 standard bearings from $\frac{1}{16}$ to $\frac{3}{4}$ in. OD are included, as well as 22 engineering bulletins discussing factors in bearing life and operation. New Hampshire Ball Bearings Inc, Dept PE, Route 202, Peterborough, NH.

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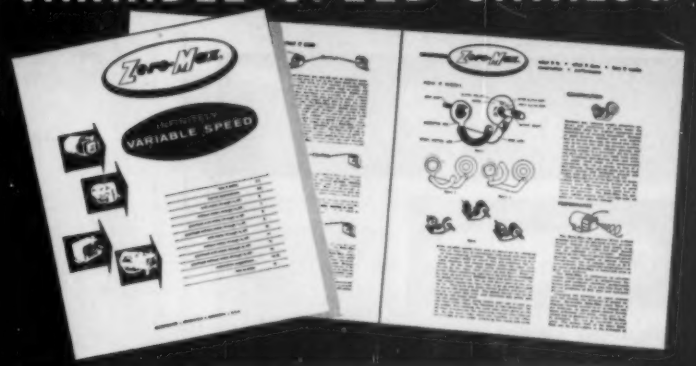

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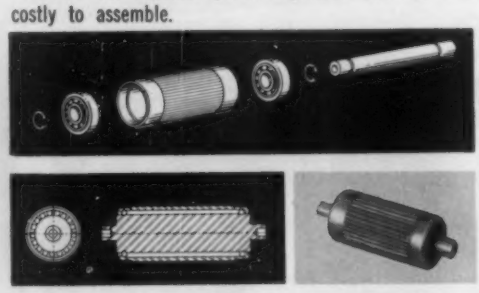

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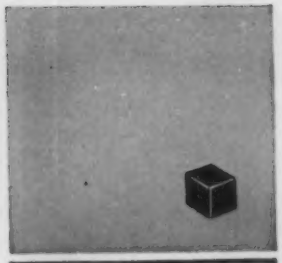

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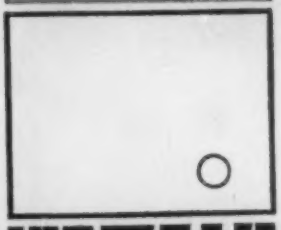

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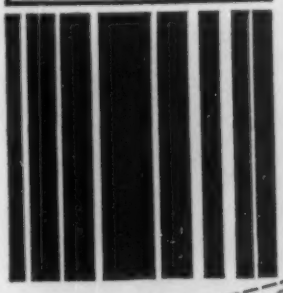

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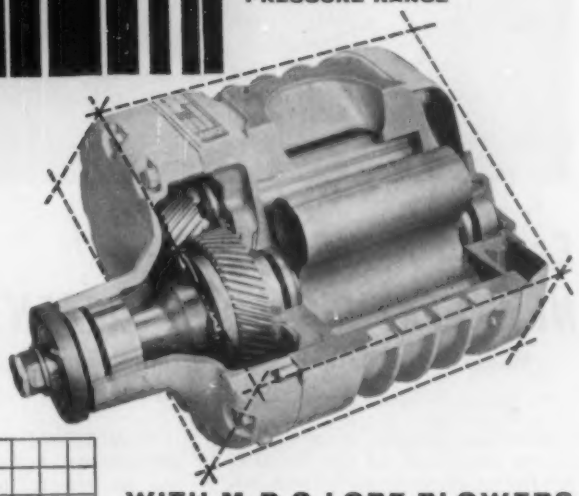

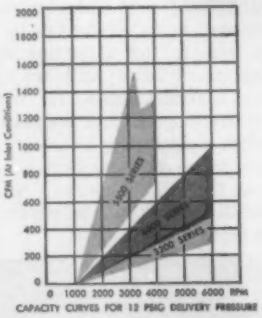

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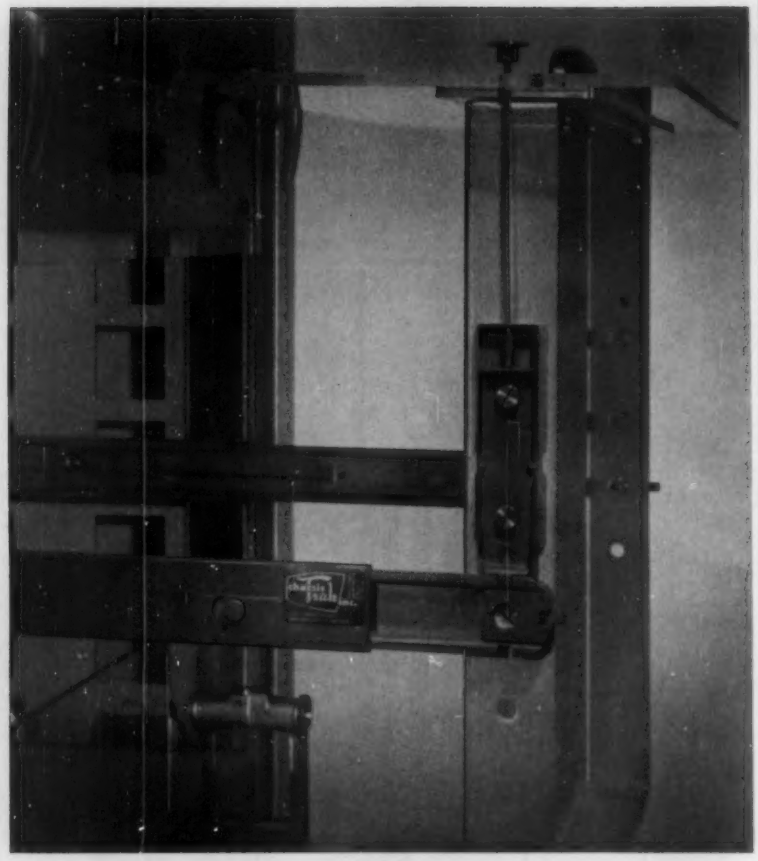

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For further information contact:

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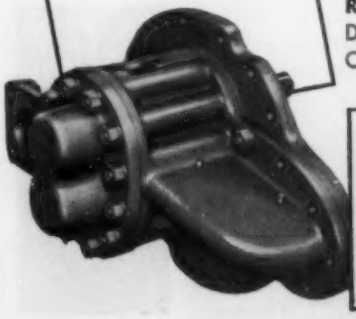

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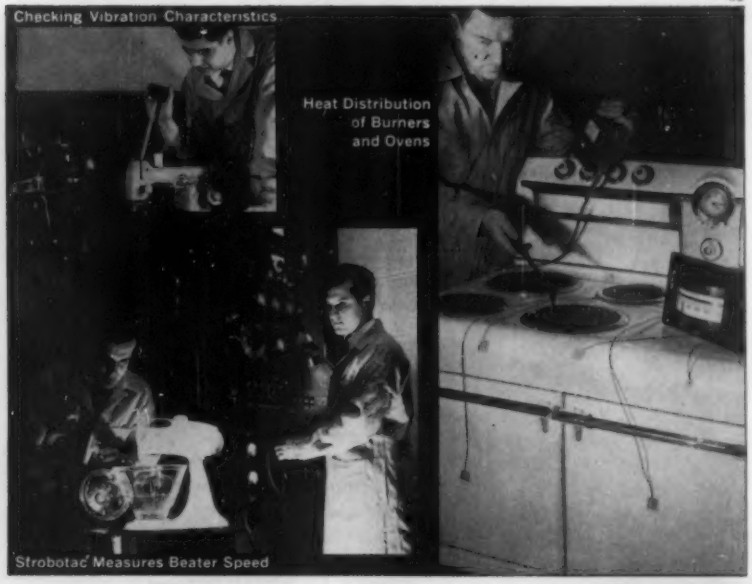

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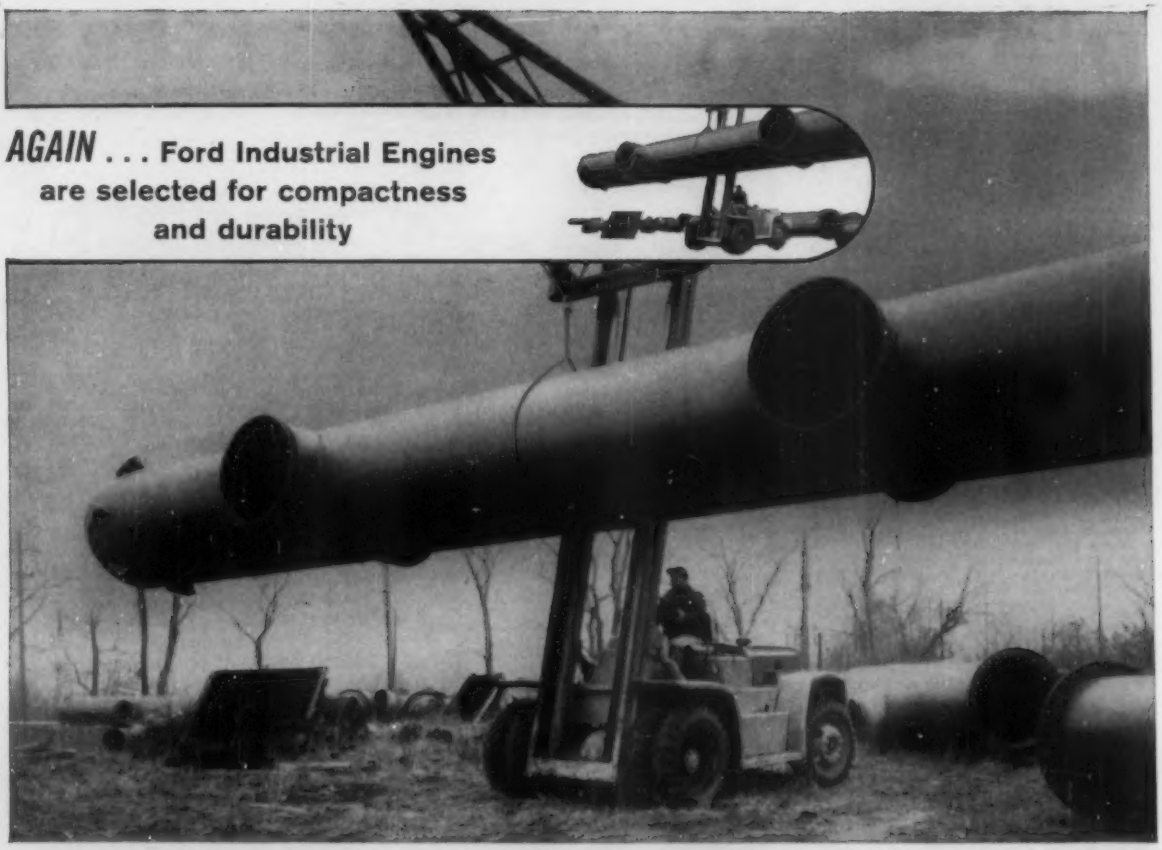

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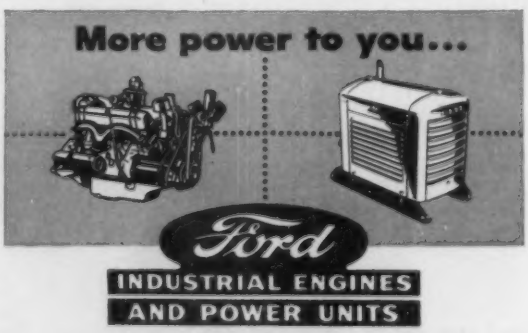

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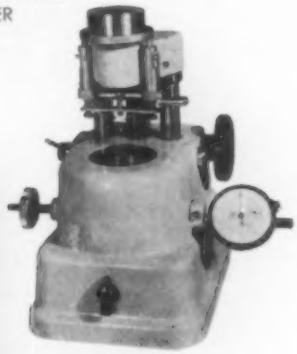

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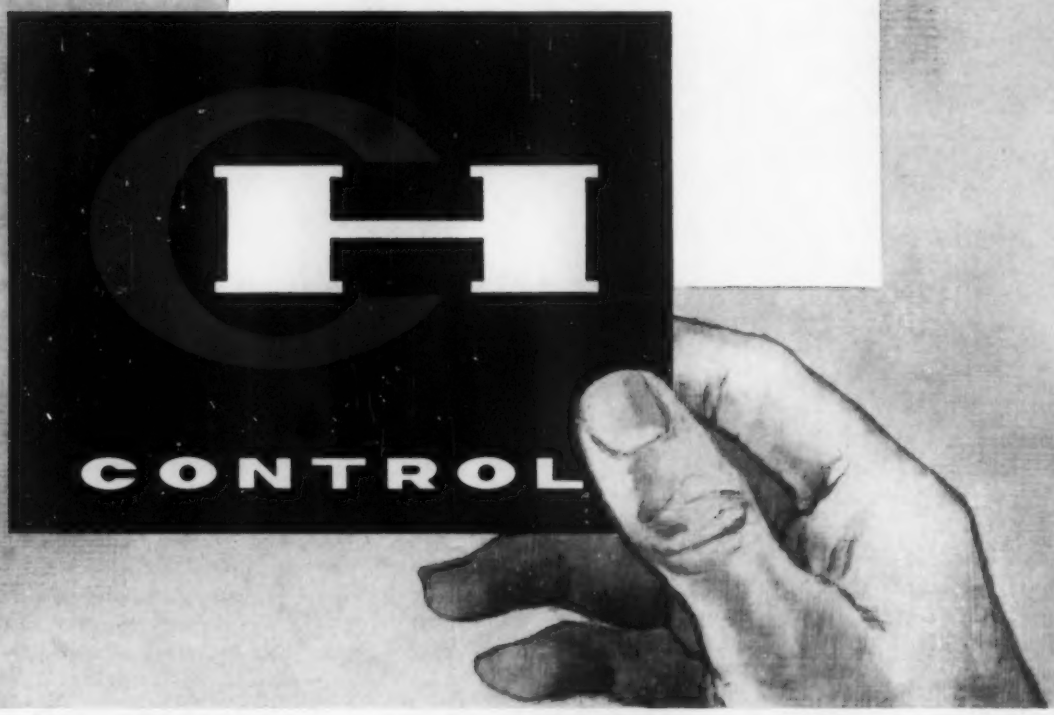

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